THE ESSENTIALS OF HEALTH

THE NEW HEALTH SERIES OF SCHOOL PHYSIOLOGIES

STOWELL

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The heart consists of four chambers, two thin walled auricles and two muscular ventricles. The pulmonary veins bring blood from the lungs to the left auricle and other veins bring blood from the rest of the body to the right auricle. Blood from the auricles flow into the ventricles beneath the aided by the contraction of the auricular walls. When the ventricles are filled they begin to contract and the blood is forced from the right ventricle through the pulmonary artery into the lungs and from the left ventricle through the aorta to the rest of the body. Valves prevent the blood from flowing back from the ventricles into the auricles and from returning to the ventricles from the arteries

THE ESSENTIALS OF HEALTH

A TEXT-BOOK ON

ANATOMY, PHYSIOLOGY, AND HYGIENE

BY

CHARLES H. STOWELL, M.D.

ADAPTED FOR CANADIAN SCHOOLS.

WITH AN ARTICLE ON THE PREVENTION AND TREATMENT OF TUBERCULOSIS

BY

C. J. FAGAN, M.D.

SECRETARY PROVINCIAL BOARD OF HEALTH, VICTORIA, B.C.

Prescribed for use in the Public and High Schools of British Columbia

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PREFACE

A SOUND mind in a sound body is the slogan of the twentieth century. In these days of intense activity one looks with admiration upon the man or woman with strong physique and vigorous intellect. The close relation which exists between mind and body, and the influence which the one is constantly exerting over the other, emphasize the necessity of the careful and thorough study of the essentials of health.

Not many decades ago the beautiful woman was supposed to have pale cheeks and a languid manner and to lead an indoor life. But this anæmic style of beauty has been supplanted by the rosy-cheeked athletic girl who spends as much time as possible in the open air. Neither does the boy who has all brain and no brawn awaken within us a feeling of hearty approval; it is certain that he is greatly handicapped in the race for success.

It was formerly thought that to obtain an education one had to risk vigor of health, but now it is known that mental labor is a real and a most important factor in our physical development. Indeed, it has been proved time and again that young men and women who enter college delicate in health succeed not only in graduating with high honors, but in becoming, by careful regard of the laws of health, strong in body.

It is the desire of the author to emphasize and explain more fully the importance of good health and its close connection with mental development. With this end in

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view, the text of "The Essentials of Health" has been thoroughly revised, and its practical hygienic teaching has been greatly elaborated.

Marked changes have also been made in the illustrations, many new ones being added, including four full-page diagrams in a new and original style and four color plates.

This text complies in all respects with the requirements of the laws regarding the teaching of physiology and hygiene, with special reference to the effects of alcohol and other narcotics on the human body.

A chapter on Tuberculosis is added to the present edition. This is done in view of the fact that the spread of the disease is mainly due to general want of knowledge regarding the value of, and reason for, simple preventive measures.

The suppression of Tuberculosis is a matter of vital and universal interest, for there are few families in which there are not vacant places caused by the early cutting off, through this fell source, of some of its loved members; and when we know, as we now do know, that the disease is preventable in the simplest way, it must appeal to all that a knowledge of its many phases should be understood not only by physicians, but by the general public.

It is to be hoped that teachers will adopt every means of making themselves thoroughly conversant with the subject, so that the different points may be made clear to their young charges, whose welfare is in their keeping.

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THE ESSENTIALS OF HEALTH

CHAPTER I

CELLS

Introductory. — We miss seeing many of the most interesting things that take place around us because they happen so frequently that we pay little or no attention to them. Probably many of us never thought much of the lives of the horses and dogs and birds which we see every day until some "animal story" or some book of natural history opened our eyes. Then we found that there was much to be known about the animals, their bodies, how they live, what they do, etc.

The human body is even more wonderful. What we now know about it men have studied hundreds and hundreds of years to learn, and indeed some remarkable discoveries have been made within comparatively recent years. There are practical reasons also for our wishing to know about our bodies and what they do, for upon the health of the body depends our ability to do our work comfortably and well. If we think it over we shall see, too, that the real success in life, which we are all ambitious to realize, must depend in part upon the ability of our bodies to do their work well and to carry out our wishes properly. The subject of our text, "The Essentials of Health," is therefore one of vital interest and importance to us all; but before we consider what we can do to keep

our bodies well and strong we must understand what they ought to do and how they ought to do it. Let us start with the smallest workers in the body. These are called the **cells.** Scientists have discovered that the whole body is composed of cells and of the products of their action. Each individual part of the body consists of cells quite characteristic in shape and size. By studying these cells, we learn much of the anatomy and physiology of the whole system.

General Description. — Some cells are so minute that very high powers of the microscope are required to see them, while others are nearly large enough to be seen with the unaided eye. In shape, there is the greatest variation. There are spherical, oval, and spindle-shaped cells; cells with branches extending in various directions, and still other cells with six equal sides. In color, there are the extremes from the black to the colorless, and from the brown to the yellowish green. There exists, therefore, a great difference in the shape, size, and color of cells.

Structure of Cells. — Living cells consist of a transparent, jelly-like material, called protoplasm. The microscope shows that there are two parts to a cell: the body, or the greater part of the cell; and the nucleus, or the smaller part in the center. The nucleus is usually spherical or oval, and, with few exceptions, is found in all cells. In rapidly growing cells, two or more nuclei are often found. The nucleus of a cell can be shown very clearly by the use of a carefully prepared solution of carmine. As the microscope shows, the carmine stains each nucleus bright red, but does not affect the body of the cell.

The Life of a Cell. — It is probable that the great majority of cells are, comparatively speaking, short-lived. We must remember that the body is constantly and

rapidly changing. Each movement of the body, each activity of a part, must cause a wear and waste of tissue; and this loss must be replaced by new material within a short time.

There are many ways of showing that the body is ever wasting away. If a drop of saliva be placed under the microscope, a vast number of thin cells can be seen. These cells come from the mucous membrane lining the mouth. The motion of the tongue, lips, and cheeks, as in speaking, eating, and drinking, removes vast numbers of these bodies. Then again, the surface of the whole body is covered with cells, many layers deep. The outer cells are easily removed by the friction of the clothing, and by the use of the sponge and the towel at the daily bath. In this way immense numbers of cells are being constantly destroyed, while new ones are as rapidly being formed beneath the surface to take their places.

A more familiar example will illustrate this point. The finger nails are composed of cells so minute that a high power of the microscope is required to see them. Each paring of the nail, therefore, must remove vast numbers of these cells; and yet, how rapidly even this hard structure grows. Thus we learn that the body is ever changing; the old, worn-out, and useless material being constantly cast off, and the new as regularly taking its place.

Some cells are much longer lived than others. It is probable that the cells found in such hard tissues as bone and cartilage undergo comparatively slow changes, while the cells in some of the glands change with great rapidity. In fact, the whole life history of a cell in some of the most active glands may be covered by a few hours.

Growth and Development. — Cells increase both in size and number. After reaching certain dimensions, however,

they cease to grow. They may then either maintain that size for the remainder of their life, or they may, by a peculiar process of division, become temporarily smaller. This process is called cell division. When a cell is about to divide, its nucleus becomes constricted in the center, assuming a dumb-bell shape. This constriction increases until the nucleus becomes divided into two nuclei. The body of the cell then undergoes the same change in form until it has divided into two cells, with one nucleus for each cell. A **process**, or bud, protruding from the body

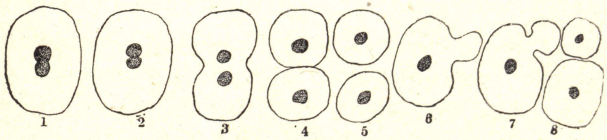


FIG. 1. — Diagram illustrating the divisions of cells: (1, 2, 3, 4, 5) by cell division; (6, 7, 8) by budding.

of a cell is still another method of division. Soon this process separates from the original cell, and a nucleus is developed within it (Fig. 1).

Some Cells have Motion. — The great majority of the cells in the body are fixed and cannot alter their shape or position. There are some, however, that not only have the power to change their shape, but also to move from place to place. These movements are known as the "amœboid movements," so named from a very minute animal called the **amœba** (Fig. 2).

The amœba is usually regarded as the lowest form of animal life. It is of jelly-like consistence, and averages from $\frac{1}{500}$ to $\frac{1}{2500}$ of an inch in diameter. It is found in stagnant water, and in water in which there is decaying animal matter. The amœba is an object of intense interest

to all physiologists, because it represents not only a single cell but also a whole individual. It is remarkable for its constant and rapid changes of form, causing it to move about in any direction. As already stated, the amœba is

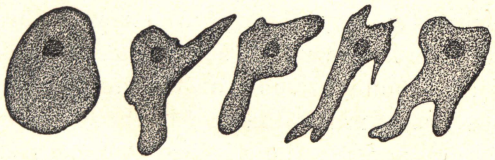


FIG. 2. — Various forms assumed by an amœba. These sketches were made from the same amœba, at intervals of a few seconds.

an animal, the lowest in the scale ; yet it moves ; it takes nourishment ; it reproduces its own kind ; and it dies.

The Function of Cells. — Each cell in the human body can take material brought to it by the blood and change that material into its own structure. To illustrate : the cells of the salivary glands can take digested food from the blood and change it into the tissue of the salivary glands ; the cells of muscle can take something from the blood and build from it true muscular tissue ; the cells of the skin can take nourishment from the blood and make from it the soft covering for the body. Thus, while a person may eat only one kind of tissue-building food, it is possible for this food to be changed into all the various structures of the body.

But the cell can do even more than this ; it can take material from the blood and change it into a substance unlike its own. For instance, a cell in the salivary glands can take material brought to it by the blood and change it into saliva ; cells in the glands of the stomach can take material from the blood and change it into gastric juice.

Composition of the Body. — Water forms a large part of the weight of the body, and there is also considerable fat. We all know that some persons have less flesh than others, but the body always contains fats; even after long-continued illness there is always some fat still remaining. Proteid, which we see in one of its forms in the white of the egg, forms a large part of the solid tissues of the body; and it is also found in some of the fluids of the body. There is also some mineral matter in the body, principally lime, soda, and potash; there is also some iron, and there are traces of other minerals.

Effect of Alcohol upon the Cells. — As the strength of a chain depends upon the strength of its individual links, so the health of the body depends upon the health and the perfect working condition of its cells. The cells of the body are bathed with blood and consequently are affected by whatever the blood brings to them. The effect of various substances upon cells similar to the cells of the body has been watched through the microscope. One observer reports that when a living cell was bathed in a liquid containing a meat extract, it expanded, made more lively movements, and appeared to be benefited. When the cell was bathed in an astringent substance, such as tea, it contracted, became nearly or quite motionless and remained so until again bathed in a nutritive substance, when it revived. But if the cell was bathed in alcohol or an alcoholic solution, it contracted, remained motionless, and could not again be revived. It was dead.

The alcohol that reaches the cells of the body after an alcoholic drink is taken is usually too much diluted to kill the cells, but it can and often does impair their vitality for a longer or shorter time, in proportion to the amount of alcohol that reaches them. A recent writer on this

subject (Dr. Overton, of Zurich) states that while the outer membrane of a cell is able to keep many injurious substances from penetrating within, it cannot prevent ether, chloroform, alcohol, and other substances of that class from coming into contact with it and injuriously affecting its substance. The more delicate the cell, the more easily and seriously it is harmed.

CHAPTER II

FOODS

Waste and Repair. — Every activity of the body, conscious or unconscious, is followed by a waste of material. And since some part of the body is always in motion, it follows that the body is always wasting away, and thus should be constantly undergoing repair. The processes of waste and repair do not always bear the same relation to each other.

Early in life, the building up greatly exceeds the breaking down; more material is supplied than is worn out and removed; the processes of repair exceed those of waste, and the body grows and develops. Later in life, the repair and waste are nearly balanced, and for a number of years the form and weight remain about the same. As old age comes on, the weight diminishes and all the forces of the body become less active. The waste now exceeds the repair.

From the food that we eat, the body must obtain the materials for building its structure and for keeping it in repair.

Oxidation and Energy. — Besides building material, the body needs material that will furnish force, or energy, for carrying on its various functions.

When a building is being erected, machinery is generally used to lift the heavy stones and swing them into place. An engine puffing and panting on the ground

furnishes the force, or energy, with which to do this, and the energy is obtained from the burning of coal or of wood in the engine.

As the burning of the coal in the engine sets free the energy stored up in the coal, so the burning of the food in the body sets free the energy in the food, which warms the body and enables it to work.

The principal *elements* which go to make up our foods are carbon, oxygen, hydrogen, and nitrogen. These exist all about us, in the earth and in the air, and generally in a free state, but in this form they do not nourish us, are not really food for us. The growing plant, however, can take up these simple elements and build its own structure from them. To illustrate: the growing rice plant takes up (from the soil, the water, and the air), carbon, oxygen, and hydrogen, and so unites or combines them as to increase and build up its own substance. The same is true of growing wheat, only in this case the plant takes up nitrogen, in addition to the carbon, oxygen, and hydrogen.

In order to do all this building up the plant requires force, and this force it derives from the sun. It is sunlight. This sunlight, or energy, will remain stored up in the rice or the wheat until these elements, carbon, hydrogen, oxygen, etc., are broken apart, or disintegrated. Then the stored energy will be set free, and will be used as heat for the body or strength for muscle.

The process by which food is broken up or burned in the body and transformed into energy is called **oxidation.**

An animal body may use as a source of energy, either vegetable structures or other animal structures. Whatever living substances an animal body can digest and absorb within itself, will yield to it a corresponding amount of energy. Man cannot obtain energy from hay, because his

digestive processes are not capable of reducing hay to a state in which it can be absorbed. We do not therefore call hay a proper food for man ; we do call it food for the cow and horse, because they are capable of digesting and obtaining energy from it.

Not every substance which can be absorbed and oxidized in the animal body can properly be called a food for that body. There are substances, for instance, which although irritating to the animal tissues can be oxidized into simpler and less injurious substances, if only small amounts are present. Such substances may yield, it is true, a certain amount of energy as they are broken up, but the amount of energy is overbalanced by the injury the body receives from being badly poisoned. It is little short of absurd, then, to speak of such substances as foods. Carbolic acid and alcohol may be oxidized in the body and so yield energy, but their chief effect is to poison the tissues, and hence they are not classed as foods, but as poisons.

Foods and poisons are thus distinguished by accepted definitions : —

A food is any substance whose nature it is, when absorbed into the blood, to build up the body or to furnish it with energy for work or for warmth, without injuring it.

A poison is any substance whose nature it is, when absorbed into the blood, to injure health or destroy life.

Classification of Foods. — All three of nature's kingdoms are called upon to furnish articles of food. The principal articles obtained from the mineral kingdom are water and salt ; from the vegetable kingdom, such cereals as wheat, corn, and oats, and a large number of vegetables and fruits ; from the animal kingdom, various meats, milk, and eggs.

For purposes of study, foods are divided into the **organic**

and **inorganic.** The organic foods are obtained from living substances, or from things which once had life. The inorganic foods are derived from inorganic substances, such as earth and water.

The Inorganic Foods

The two principal inorganic foods are water and salt. These are found in many forms of food and are also added to the food in cooking.

Salt. — Salt is found in all the tissues and organs of the body, except in the enamel of the teeth. It is estimated that there is nearly one quarter of a pound of salt in the entire body. In a small amount, salt is present in nearly all the organic foods in use, but not in sufficient quantity to meet the demands of the system. That salt is a necessary food is indicated by the natural craving for it, not only in man, but in the lower animals as well. Wild animals on the hills and prairies will travel many miles in search of salt; while the domestic animals, like cattle and sheep, will come quickly to the farmer's call, expecting some of this necessary food. Such animals as sheep and cows, which live chiefly upon the grasses, fail to obtain a sufficient supply of salt with their food; those animals living principally upon meats receive all that they need, as salt is already in the meat itself. Such animals may even have a repugnance for salted meats.

Salt gives a flavor to the food and stimulates the appetite. Food may be very nutritious, yet if it be tasteless it is not eaten readily, and is digested with difficulty.

Water. — Water constitutes nearly three fourths of the weight of the entire body. It is universally present in all the tissues and fluids of the body. There are many reasons why water is so important. All the food that

we eat must be dissolved before it can be digested. Therefore water is the most important substance used for food, as it is the one universal solvent. The water in the tissues holds in solution numerous substances, both the foods and some of the waste materials of the body. Through the blood and tissues water becomes a circulating medium for conveying the foods held in solution to all parts of the body, and for taking away from the tissues the worn-out and useless ingredients.

Water gives elasticity to the bones, the muscles, the tendons, and the other tissues. The craving for water is greater than for any other food, and if deprived of it, a person will die sooner than if deprived of solid food.

A large quantity of water is taken into the system during each day. Some of this is taken purposely, as a drink, while a large amount is taken unconsciously with the food. To prove the truth of this latter statement, we have only to remember that one half the weight of beef, three fourths the weight of potatoes, and nine tenths the weight of milk, consists of water. A healthy man takes, on an average, about two quarts of water each day.

Sources of Water. — Rain water most closely resembles distilled, or chemically pure water. It usually contains a small amount of carbon dioxide. Spring water contains a considerable amount of mineral substances and carbon dioxide, the latter giving to spring water its fresh taste and aiding in dissolving the mineral substances as the water permeates the soil. Spring water contains but little oxygen; therefore, many vegetable organisms are usually found in it, while animal life, which requires much oxygen, is poorly represented. Spring water may bubble to the surface of the earth, or it may be brought within reach by some mechanical device such as a pump.

The Purity of Drinking Water. — Drinking water should be colorless and without the slightest odor. Chemically pure water, however, is not pleasant to the taste ; it lacks the snap and tartness of spring water. Then, too, the presence of some minerals in solution is useful to the system. Lime is important, for instance, in the formation of teeth and bone, and drinking water which contains lime, if it is not present in excessive quantities, must be regarded as healthful, especially in early life, when the tissues are developing.

On the other hand, lead is a very dangerous ingredient of water. Water that has stood in lead pipes should never be used for drinking purposes. If it is necessary to use lead pipes, then the water should be kept running, or a large quantity should be drawn off before any is used. There is no reason for supposing, simply because water has no odor and looks clear, that it does not contain in solution substances of a most poisonous nature.

Organic matter in a state of decomposition may be present in water. When there is any danger of this, it is much better to boil the water for ten or fifteen minutes, and thereby destroy the minute germs. During an epidemic of typhoid fever, it is a wise precaution to drink no water that has not been boiled.

Other Inorganic Foods. — There are other inorganic foods, besides water and salt, such as the various chemical salts, including the salts of soda, potash, and lime.

The Organic Foods

The organic foods are derived from the animal and the vegetable kingdoms. For convenience they are usually divided into two classes, called the **nitrogenous** and the

non-nitrogenous foods. We shall understand the reason for making this division when we remember that nitrogen is the basis of all tissue-forming food; that is, by the nitrogen in our food the tissues of the body are built up and are kept in repair. Without nitrogen the boy would not grow and the man would not be able to repair the tissues of the body, which are constantly breaking down as we work. We see, therefore, that the foods which we have classified as nitrogenous might also be classified as the **building** and **repairing foods.**

The non-nitrogenous foods are equally necessary to the health of the body, for they are the foods that enable the body which has been built up by the tissue-forming foods to perform its work. They are sometimes called the **fuel foods**; and we have already learned that they are oxidized in the body. It is true also that the proteids may be used, to a greater or less extent, as fuel foods, if the body needs extra fuel.

When we begin to classify foods in this way, we must, however, remember that one article of food often contains many different food substances, and so will properly fall into several different food divisions. Take, for instance, wheat bread as it is usually made. We think of it as a very simple food, but it contains tissue-making material (proteid) and also fuel materials, such as starch, besides much water, which we have learned to be an inorganic food, and some salts. So while, for convenience, we shall proceed to take up the foods we naturally eat, placing them in the usual divisions, we should remember that this classification is for convenience and is not complete or exclusive.

CHAPTER III

THE NITROGENOUS FOODS

The Proteids. — The nitrogenous foods are generally called proteids. They include such foods as the lean meats, eggs, and milk. There are four forms of proteids which we find commonly eaten. It is not important to distinguish between the action of each in the body, but it may be of interest to name them. They are, (1) **albumen**, which is found in its purest form in the white of the egg; (2) **myosin**, the lean part of meat; (3) **gluten**, found in cereals; and (4) **casein**, the thick white substance, or curd of milk. A diet cannot be nutritious that does not contain the proper proportion of proteid food.

We have spoken of the importance of proteids as the foods required to build and to repair the body. Scientists who have studied the body tell us that proteids form the chief part of the muscles of the body and are present in nearly all its fluids. This being the case we can see that the body, if kept in health, must be supplied with ingredients that are found in its tissues. This does not mean, however, that we should eat chiefly proteids. There are nations, notably the Chinese, in which the poorer people probably do not eat a sufficient quantity of proteids, but scientists tell us that in this country, as most of us live, we more often take too much proteid than too little. It used to be the popular impression that in order to do good work the body needed a great deal of meat. Experi-

ments have shown, however, that the necessary proteids can be secured from eggs and from cereals as well as from meat. Many people find that they can to advantage cut down the amount of meat usually consumed per day.

Milk. — The "model food" is the name often given to milk; and it is true that no food can surpass it. Since it contains all the necessary food elements, it will support life longer than any other single article of diet. It must, however, be taken in larger quantities than the other proteids, for it contains a large amount of water, nearly nine parts in ten; it has a considerable amount of fat, most often used in the form of butter; a sugar, known as milk sugar; minerals; and proteids. The mineral matter consists largely of lime, so essential to the formation of the bones when they are growing.

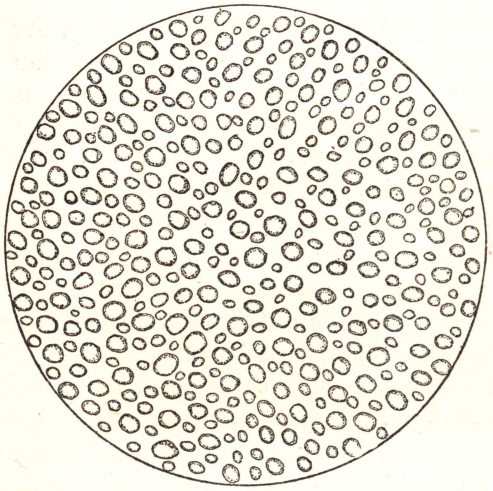


FIG. 3. — Milk, highly magnified.

The nitrogenous matter in milk consists almost entirely of albumen and casein. If any acid be added to milk, the casein is thrown down in a coagulated form, and the milk is said to be curdled. The milk curdles without the addition of an acid if it is exposed to the air for a few hours in a warm room. This is because of the develop-

ment of lactic acid in the milk. The action is the same as if the acid were added intentionally, and the casein thus coagulated. From this coagulated mass, or curd, cheese is made. The fat of milk consists of vast numbers of minute oil drops. Under the microscope, these appear as small round globules floating in water (Fig. 3).

Milk should be the principal food of children, while for adults it may be used as a drink with the ordinary meals. Warm milk may take the place of a cup of coffee; cold milk is a good substitute for ice water. Some people

An outdoor milking scene on a model dairy farm.

claim that they cannot use milk, as it disagrees with the stomach and interferes with the action of the liver. These troubles are easily prevented by using only a moderate amount, and by adding to it a dessertspoonful of lime water to a glass of milk.

Care of Milk. — It used to rest with the farmer or the dairyman to see that the milk he offered for sale was clean and pure. People came, however, to appreciate the great importance of the purity of the milk they used. They learned that milk very readily absorbs gases and

impurities of various kinds, and further, that it may also be the means of communicating disease, either from being adulterated with impure water, or from having absorbed injurious gases or other impurities. Care is all the more necessary as we use a great deal of milk without cooking it, — a process which would destroy any harmful germs. Consequently much attention has been given of late to the proper care of milk, and in many places there are laws forbidding the sale of milk that does not reach a

Interior of the milking house of a dairy farm. (The cows are never milked in the barn where they are stabled.)

certain standard of richness and purity. Such supervision of our milk supply has resulted in special attention to every important detail, such as the care of the cows, the cleanliness of the barns in which they are stabled and the places in which they are milked, absolute cleanliness on the part of the milker and in the handling of the milk. In many dairy farms all these matters are now arranged in a most careful and scientific manner. The illustration on page 17 and the one above show two actual milking scenes at a model dairy.

Care, however, cannot cease when the milk is delivered in perfect condition to the consumer. It must be kept cold, and in a room or ice-chest that is absolutely clean and free from odors. It is a safe precaution, when one is not sure of the purity of the milk used, to scald it as soon as it is received; that is, heat it to the boiling point, but do not boil it. Then cool it quickly and place in the ice-chest, covered. Milk dishes should always be scalded before they are used. Any germs that get into milk develop quickly during the heat of the summer months, producing severe stomach and bowel diseases, and causing very many deaths among young children. As these germs multiply and grow more rapidly when the milk is warm, great care should be used to put it in a cool place as soon as it is received and to keep it cool. It ought to be kept in a refrigerator.

As the refrigerator is a place for keeping food it should always be as clean as it can possibly be made. All the food should be in dishes or receptacles of some kind. No crumbs or particles of food should ever be allowed to remain on the shelves. At least once a week the refrigerator should be thoroughly washed with hot water. The importance of this — especially when there are children in the house who depend upon milk for a diet — can hardly be overestimated. Keep the refrigerator spotlessly clean.

Eggs. — (Eggs are easily digested and very nutritious.) They are most digestible when soft-boiled in the shell, or when broken into boiling water. The principal differences between the white and the yolk of the egg are these: the white contains no fat, the yolk is about one third fat; the white contains albumen and a large percentage of water, the yolk contains no albumen, and only about half as much water as the white.

Meats. — The meats used for food are rich in nitrogenous ingredients, together with fat and mineral matter. The meats differ in their digestibility and in their nutritive value. Beef is regarded as the best meat for general use. When tender beef is properly cooked, it is easily digested and very nutritious. Mutton ranks next to beef.

Veal is not easily digested, neither is it so nourishing as beef and mutton. Pork is not readily digested; the fibers of the lean meat are too compact, and the fat is likely to be in excess. A large class of people, however, eat it freely. To those who exercise much, and those who have strong digestive powers, pork appears to do no harm. Oysters contain only a small proportion of nourishment, but they are easily digested, when eaten raw, and are very pleasant to those who have acquired a taste for them.

The Cereals. — The cereals, comprising chiefly wheat, oats, corn, and rice, are most important foods. They consist of nitrogenous material, starch, sugar, salts, and fat. The starch is seen as the white center of the grain, surrounded by a husk. The husk consists of a woody material and is quite indigestible. The nitrogenous portion of the grain is situated between the husk and the starchy center. Wheat flour would be much more nutritious if only the husk, or bran, were removed, and the layer containing the nitrogenous matter and the gluten, oil, and salts retained with the starch. The flour and the bread made from it would not be so white, but would be more wholesome. The gluten, which gives the adhesive, jelly-like quality to the cereals, is very abundant in wheat, forming about twenty per cent of the whole grain.

The grains vary in their proportions of nitrogen and starch; but their value as a food does not depend alone

upon the amount they contain of any single nutritive ingredient. There should be such a variety of substances as will form the best combination for the nourishment of the body.

Wheat excels all the cereals in nutritive value. It is easily digested and, with the exception of milk, it comes nearest to the standard of a perfect food. It is well supplied with nitrogenous material; contains but a small proportion of water; has a large amount of starch; and also considerable mineral matter and some fat. There is, however, a deficiency in the amount of fat it contains; therefore this must be supplied by putting butter on the bread. The proportion of water is so small that a given bulk of wheat is richer in solids than any other food. Probably the best test for a good wheat is the kind of bread it will make.

Oatmeal contains a large amount of nitrogenous material, ranking in this regard nearly or quite equal with wheat; but it contains also a considerable amount of woody or fibrous material, which interferes with the digestion of it and lowers its nutritive value. Since it lacks adhesive qualities, it cannot be made into bread. Yet it is a wholesome food, and to most persons agreeable.

Corn contains less nitrogenous material than oats, but it has more starch. **Rice** consists of ninety per cent of starch with scarcely any nitrogenous material. When taken with some proteid, such as meat of any kind, it is a valuable article of diet; it is easily digested and is also very cheap.

Vegetables. — Peas and beans are very nutritious, since they contain a good amount of proteid and of starch. They consist of such solid matter, however, that they are not

easily digested. When used, they should be cooked a long time, and should be thoroughly masticated.

Potatoes consist of from seventy to eighty per cent of water ; the remainder being nearly all starch, together with a small amount of mineral matter, proteid, and salts. Although they consist so largely of water, yet they are the most generally used of all vegetables. This is because they can be obtained at all seasons of the year, are very cheap, and agree with most persons. They should never form the exclusive diet ; but, when used with some fat, as butter or meat gravy, and with salt, together with some food rich in nitrogenous matter, they form a most valuable adjunct to the table.

Turnips, cabbage, parsnips, onions, and other vegetables are added to the list of foods in order to give suitable variety. Their nutritive value is low, and they are not easily digested.

Fruits. — Apples, peaches, pears, and other fruits are valuable foods in many ways. They contain a considerable amount of sugar and of mineral matter, while their acids give each its characteristic taste. These acids serve to stimulate the appetite and promote the flow of gastric juice, while the great amount of water they contain serves to quench the thirst. Ripe fruits in their season are most beneficial ; overripe and unripe fruits, on the other hand, are often the cause of serious trouble. Much of the danger of unripe fruits can be removed by cooking.

CHAPTER IV

THE NON-NITROGENOUS FOODS

THE non-nitrogenous foods consist of starch, sugar, and the fats. They are, as already stated, the fuel foods. There is a natural craving in the body for these foods, and experiments have proved that they cannot be dispensed with for any great length of time without serious injury to the health. This seems to be especially true when the body is growing rapidly.

Fats. — Some individuals do not digest the fat of meats readily, yet they can use butter and milk. Others are able to digest such fatty foods as bacon, or the fat of other meats. Fat has great heat-producing power, therefore it is most used where the climate is cold and severe. Many children who are given enough food to eat suffer from what we might call "fat-starvation." Perhaps they have a foolish dislike of fat, or it may be that their parents do not realize that an active child needs much fuel food, to maintain all his natural activity.

It is probable that some of the fat in the body is derived directly from the fat of the food; that is, the fat is digested, absorbed and deposited in the tissues. But it is equally true that fat may be formed in the body from foods which are without fat. This is proved to be a fact with animals, because the amount of fat, or butter, found in the milk of the cow far exceeds the amount of fat taken as food.

It is true, too, that some persons become very fleshy, while others, with the same diet, remain lean. In many families there is an inherited tendency to grow fleshy. It is probable also that, in some cases at least, more food is taken than is necessary for the normal uses of the body. A deposit of too much fat is attended with inconvenience and frequently with danger.

Starch. — Pure starch is a fine, white powder, consisting of minute granules. When examined under the microscope, the granules are seen to vary in size and form,

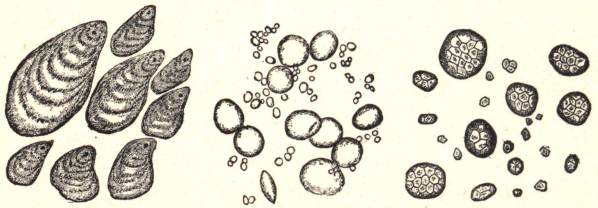


FIG. 4. — Starch grains: (1) from the potato, — potato starch grains; (2) from wheat, — wheat starch grains; (3) from oat, — oat starch grains.

according to the kind of starch. Thus, by the appearance of the granules, it becomes possible to tell from what vegetable the starch was obtained. The three illustrations given (Fig. 4) show these marked differences. Each kind of starch is magnified the same number of times, or about five hundred diameters. The granules are very minute, those of rice starch being not over $\frac{1}{6000}$ of an inch in diameter. When mixed with water, the granules swell and form a paste; when boiled with a large amount of water, they expand greatly, and can no longer be seen. The destruction of these granules is a great aid to their digestion. Prolonged cooking changes the starch into a substance called dextrin. This is easily transformed by the digestive juices in the body into grape sugar.

The brown crust of the bread is the starch of the flour changed into dextrin by the prolonged exposure to heat, hence it is more easily digested than the softer parts of the bread. In order that the starch granules may be completely broken up, all starchy foods should be thoroughly cooked. A too exclusive diet of starchy foods is likely to impair the digestive powers ; for the digestive juices are unable to change promptly large quantities of starch into sugar, and consequently the sugar is slowly absorbed if it is present in too large quantities. This gives rise to the formation of gases and acids, and dyspepsia then follows.

Sugar. — Sugar is closely allied to starch, both in its chemical and physiological relations. In the living plant, the sugar and the starch represent the same nutritive material, though under different conditions ; the sugar is in the form of a liquid, and the starch is in the form of a solid.

There are three principal varieties of sugar, — cane sugar, grape sugar, and milk sugar. Cane sugar is obtained from the juice of the sugar cane. It is the variety in ordinary use. It is made also from the juice of the maple tree, and is called maple sugar. It is the most soluble and the sweetest of the sugars. Grape sugar is found in great abundance in the juice of ripe grapes. It is generally distributed in the sweet juices of many fruits and flowers. This is the reason it is found in honey, although cane sugar is also present. Grape sugar is found in some of the animal tissues and fluids, as in the liver and the blood. This is the form of sugar which is made in the body by the digestion of starch. The third variety, the sugar of milk, is found only in milk. Its sweet taste is not very marked.

While it is true that a considerable quantity of sugar is likely to disturb the stomach, yet it is equally true that a certain amount is very desirable. The natural desire for sweet things is universal and it is based on a demand of the system for this food. Appetite is not always a safe guide, however, when the taste of a food, like that of sugar, is so agreeable. If boys and girls eat a little less sugar than they desire they will be on the safe side. If candies are desired, eat only those made from pure sugar; but it is better to try to satisfy the craving by eating ripe fruit. There is no danger that the teeth will be injured by the use of sweet foods, if they are cleansed after eating, as should always be done.

Bread. — Bread is often called the staff of life, because it contains so many nutritious elements, being deficient only in fat. Thus it follows that bread and butter make a very complete diet.

In making bread, the flour is mixed with water until a dough is formed. Salt and yeast are then added. The dough is set aside in a warm place until fermentation is well established. In the process of fermentation, the nitrogenous ingredients begin to decompose and act as a ferment on the starch, which becomes, in part at least, changed to sugar. The sugar is further decomposed into carbon dioxide and alcohol. The carbon dioxide forms bubbles; these force their way through the dough, or sponge, making the bread rise. The dough is now placed in an oven hot enough to stop fermentation at once. The alcohol is all driven off by the heat, and much of the water also. The bread is then said to be baked.

Yeast, however, is not essential to the making of bread. Unfermented bread is made by mixing with the dough a powder composed of an acid and an alkali, so that after

the powder is moistened in the bread, the acid and the alkali form a new compound, and carbon dioxide is set free.

In aerated bread, the carbon dioxide is forced into water and the flour then mixed with this water under pressure. When the dough is heated, the carbon dioxide expands and makes the bread spongy.

Bread made from unbolted flour is very nourishing, as it contains all the gluten of the wheat, but the presence of the bran makes it difficult to digest, so that it should not be used by persons with weak digestive powers. Hot bread is likely to form a paste in the mouth, and as the digestive juices cannot then work on it readily its digestion becomes difficult.

The Amount and Kind of Food. — No rule can be laid down saying positively just how much of each kind of food must be taken ; but if the body be in a healthy condition, an amount should be taken sufficient to satisfy the appetite. The appetite, however, is not always a safe guide, because by irregular habits, by overeating, and by eating improper articles of food, it becomes variable, and is then an unreliable test. If persons would form the habit of eating a regular diet of plain, wholesome food, there would be far less dyspepsia with its attending disturbances of the nervous system.

The quantity of food must vary with the amount and kind of exercise. A good rule is this : Learn which foods are wholesome, and how they should be cooked; then watch yourself for a time, and decide what and how much it is wise for you to eat. Some persons require only a small amount of food to keep them in good health, while others require much more. This is partly because one person uses up more energy than another;

it may be in work, in exercise, or in worry. Another difference is in the proportion of the food taken that is assimilated by different persons; for after all it is not the amount of food we eat, but the amount digested and taken up by the body that determines whether we are overfed or underfed. Sickness is caused by overeating, as well as by eating things which are harmful. Remember that a mixed diet is better. Habit and custom have altogether too much to do with determining the kind and amount of food that people eat.

Cooking. — It is necessary to cook most kinds of food, in order that they may be properly digested. Oysters and certain ripe fruits are the principal exceptions to this rule. Cooking coagulates the albumen in the foods; it renders the fatty tissues more fluid; it changes the starchy foods into a pulpy mass, and it breaks up the harder tissues of the vegetables. Thus the foods are softened, and are more easily masticated. Cooking also brings out distinct and agreeable flavors in foods.

Methods of Cooking. — In broiling, roasting, or boiling meat, it is desirable to retain in the meat as much of the nutritive properties as possible. This can be done by applying great heat at first, which produces a rapid coagulation of the albumen on the surface, thus forming a crust, through which the nutritive juices of the meat cannot escape. Afterward the cooking should proceed with a less degree of heat, until the meat is cooked to please the taste.

When meats are cooked too thoroughly, their natural juices are driven off by the prolonged heat, and their albuminous matter is rendered hard and dry. Such meats are masticated with difficulty and digested slowly, while much that is nutritious is lost.

Broiling is the best method of cooking meat; roasting is nearly as good. Vegetables and the coarser meats can be made very tender by prolonged boiling; remember that they should be placed at once in boiling water, and then allowed to cook slowly in water that is kept barely above the boiling point.

When we are studying about the best foods and how they should be cooked, we must not overlook the real reason why these matters are so important. That is because, within certain rather variable limits, the body can manufacture, day after day, only about so much energy or force. If we choose our food so badly that an extra amount of energy is needed for the work of the digestion (about which we shall learn more later), then there is so much less energy for other work that we want to do. When there is so much good, digestible food to be had, it is foolish to make our bodies waste their energy on food that is indigestible in itself or is made so by being cooked improperly.

Frying is the least desirable of all the methods of preparing meats and other foods; in fact, it is an actually injurious method. The fat in the meat, or the fat in the frying pan, penetrates the lean portions of the meat and surrounds each particle with a layer of oil. As oil is not digested in the stomach, it follows that the meat with its oily covering must pass out of the stomach before the outer coat of oil can be completely removed. Certain fatty acids which are likely to prove injurious also are developed during the frying process. When food must be fried, the fat should be boiling hot when the articles are put into it, and it should be kept boiling during the entire cooking. Thus by forming a hard outer coat at once, the fat is not so likely to penetrate deeply.

In making soups, it is better that all the juices be extracted from the meat, — a result just the opposite of the one desired in broiling or roasting. Therefore the meat should be cut into small pieces and placed in cold water at first, the water being allowed to come gradually to a high temperature. In this way no layer of coagulated albumen is formed on the outside, and all the juices are brought out by the water.

Economy of Food. — There is much that might be said about the economy of food that cannot find a place here, but every one who cooks ought to study that problem carefully. Many times, however, the importance of absolute cleanliness in the preparation and care of food is not appreciated. As the kitchen is the place where food is prepared for the table, everything in it should be clean and neat. Stoves should be kept polished; all the cooking utensils should be models of neatness; the broom and the mop should be frequently called into use, and none of the refuse from preparing the meats and vegetables should be allowed to stand in the room for any length of time. The one who does the cooking should, of course, always be tidy in dress, and above all should always keep the hands and nails very clean.

Frequently much of the food left unserved at the end of a meal is wasted. This is unnecessary, since there are so many appetizing ways in which food may be prepared for the table a second time. To waste food is expensive, and it is wrong as well. There is another form of waste for which the cook is not responsible. Too often we are careless about the amount of food that we serve to ourselves, or have placed on our plates at meal time. Do not take more food than you are quite sure you can eat.

Another way of wasting good food is equally common; that is, eating it improperly. Those who bolt their food down are not the only offenders here. If we choose the right food and eat it slowly, we may still lose — that is waste — much of its value to us by allowing ourselves to be in a fretful, anxious, or ugly frame of mind, as we eat. The saying that we swallow our thoughts with our food, has much sense back of it. A merry breakfast table gives all the family a good start for the day.

CHAPTER V

ALCOHOLIC DRINKS

Bacteria and Other Cells. — The tiny seed planted in the ground in the spring becomes, before the summer is ended, a plant very many times larger than the seed from which it sprang. You touch the stalk, the leaves, the fruit, and wonder where all this material came from. It was built up largely of gases, which you can neither see nor handle, of water, and of a few dissolved minerals, which the plant sucked up through its roots from the moist earth. The builders were cells, similar to those that build up the animal body. If you cut tiny slices from the stalk, the leaves, the fruit, or the root, and examine them under the microscope, you can see the different kinds of vegetable cells that constructed the plant.

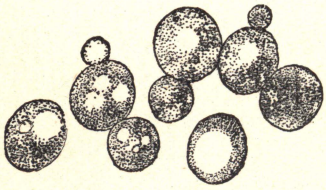


FIG. 5. — A yeast plant, magnified.

In the fall, the frost chills these cells and they stop their work. If the plant is an annual, it dies. Other cells then begin to work, — not cells that build up, but cells that tear down and cause the plant to crumble and fall apart. The gases and minerals then separate and go back to the earth and air from which they came. The work of these destructive cells is called according to the material they work upon by various names, such as **rot**,

mold, putrefaction, fermentation. These are all some form of decomposition or decay. The work which they accomplish is the setting free of the building materials, the gases, the water, and the minerals, used by the building cells in forming the living plant or animal body.

Among the different kinds of cells that cause decay is one that sets up the process of fermentation in certain sweet liquids. Baker's and brewer's yeast is composed of this kind of cells, and another species, called **wild yeast,** floats about in the dust of the air at certain seasons of the year and falls with the dust upon the surfaces of fruits. See Fig. 5.

Cider. — The juice of apples, when first pressed from the fruit, consists chiefly of water, of more or less sugar, and of a small amount of acid. When apples are ground and their juice pressed out, the wild yeast cells that were in the dust on their stems and skins are washed into the juice. If this is left standing in moderately warm air, these yeast cells will soon begin their part in the process of decay. They cause the sugar of the liquid to break up into two simpler substances, **carbon dioxide** and a poisonous liquid called **alcohol.**

While this change is going on, the apple juice appears to be full of tiny bubbles rising toward the top, which make the juice look like water that is just about to boil; hence the name **fermentation** (from the Latin "to boil") has been given to this process. Apple juice that has fermented is called cider.

The amount of alcohol in cider depends upon the length of time the yeast has been at work and upon the amount of sugar in the juice for it to work upon. Ordinarily, in a few hours after the cider comes from the press, bubbles of gas can be seen rising through it, indicating

that the yeast cells are at work breaking up the sugar and that some alcohol is already present in the juice.

"What is the harm in drinking sweet cider?" is a question frequently asked. If one chooses to use in his own home a small hand press and extract at one time only as much juice as can be used within five or six hours, and if the press be cleaned immediately after each using, so that no material is left in it to ferment, he can have sweet cider or apple juice that will do no harm. But cider that comes from a cider mill may contain considerable alcohol and still be called sweet, being more or less contaminated with the fermenting and decaying matter about the mill. Then, too, the yeast multiplies with almost incredible rapidity, a few hours being long enough for a million cells to be produced from a single original cell. The change of the sugar into alcohol and carbon dioxide goes on with corresponding rapidity, for the life processes of the yeast cells involve the breaking up of the sugar to get from it the oxygen needed for their life and growth.

The harm, therefore, in drinking sweet cider is that one is almost sure to get more or less alcohol, and alcohol has the power, even in small quantities, to set up a craving for its continued and increasing use. Before the revelations of the microscope, nothing was known of the existence and mode of life of the yeast and of other kinds of ferments. People knew that apples were good to eat, and they naturally supposed the juice of the apple to be equally healthful as a drink. They could not understand why the young man who had always had plenty of cider to drink at home should take to going to the tavern or saloon for whisky or rum. But when the microscopist discovered the germs that cause fermentation, and the chemist analyzed the results of their work, it was then

learned that every fermentation changes the character of the substance fermented. Hence, cider that has undergone fermentation differs from the apple juice from which it was made, because it contains alcohol, a poison, in place of sugar, a food. The danger in drinking cider is that the alcohol it contains may arouse the insatiable, destructive, alcoholic appetite or craving.

The same germs that change expressed apple juice into an alcoholic liquor will cause a like change in the juice of grapes if it is pressed out and allowed to ferment. The dried yeast cells floating in the air settle upon the surface of the grapes, and when the juice is pressed out, they are washed into it and soon set up the process of fermentation, which changes the sugar of the grape juice to carbon dioxide and alcohol.

Many people enjoy unfermented grape juice, which is made by boiling the juice as soon as it is pressed out of the grape. This kills the yeast cells. Then, while boiling hot, the juice is sealed in air-tight bottles and thus fermentation is prevented. Perhaps in time this unfermented, non-alcoholic wine will come to take the place of the fermented. It will be a blessing to the race if it does, for as it does not contain the thirst-creating poison, alcohol, it will not carry within itself the cause of an imperative and progressively increasing demand for more.

Alcoholic wine is to be shunned by every one who values the power of self-mastery, of a clear brain, and of a sound body.

Beer. — The process of fermentation is employed also to obtain alcoholic drinks from grain. These do not, like the fruit juices, contain sugar ready formed within them. They contain starch which can be changed to sugar by

applying sufficient heat and moisture to sprout the grain. When this occurs, the brewer kills the sprouts with a higher degree of heat, grinds the grain, then called malt, and soaks out the sugar thus obtained with water. To the resulting sweet liquid, hops are added and yeast, which sets up the process of fermentation. The sugar is changed into carbon dioxide and alcohol, which here, as in every

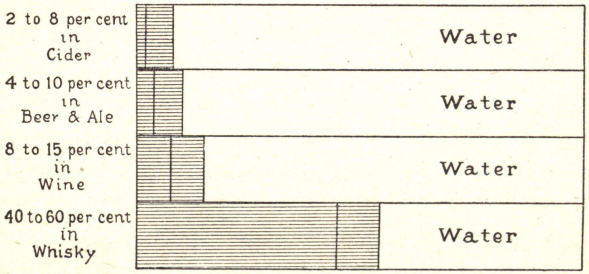


FIG. 6. — A diagram of the proportionate amount of alcohol and water in various alcoholic liquors.

liquid containing it, has the power of creating the imperious craving for more, while it at the same time weakens the will necessary to resist the craving.

Much emphasis is sometimes laid on the great difference between "pure" beer and that which has been "adulterated," but none of the adulterations ordinarily used are as important as the ever present alcohol, because they are found in much smaller amounts, and do not possess the subtle, dangerous, thirst-compelling power of alcohol. A professor in one of our American universities,[1] who made a special investigation of the matter of adulterations, said that "ethyl [common] alcohol alone is poisonous enough to account for all the evils of alcoholism."

[1] Professor Abel, of Johns Hopkins University.

Germany is often referred to as an example to other nations of the advantages of the free use of the best beer. Plenty of cheap beer, it is said, will result in less alcoholism, because the people will use more beer and less of the stronger drinks that contain more alcohol. Within the last few years, careful investigators in Germany have been looking into the results of beer drinking in that country, and this is what one of them reports: [1] —

"We now drink nearly four times as much as our yearly outlay for army and navy. And what does the alcohol business give us in return for this tribute? An increasing number of criminals, an army of sick and diseased, a depraved future generation, a deformed population. To see it, one needs only to take a single walk around Munich, the city that lies in the fetters of the brewer."

Distilled Liquors. — The amount of alcohol in fermented liquors is limited by the amount of sugar in the original liquid to be turned into alcohol and carbon dioxide, and also by the fact that ordinary yeast plants cannot work in a liquid that contains more than twelve or fourteen per cent of alcohol. They are either killed or rendered inactive by the poison they have themselves produced. So liquors containing a larger per cent of alcohol are made by distilling the fermented liquors.

Alcohol vaporizes at a lower temperature than does water. By heating a fermented liquid to the vaporizing point of alcohol, the latter rises in the form of vapor, and is conducted through pipes to a place of lower temperature, where it turns back into liquid form again. Much of the water with which it was formerly mixed is left behind in the heated vessel, but not all, for some of the water turns to vapor and passes over with the alcohol.

[1] Dr. Hermann Popert, LL.D., of Hamburg.

Brandy, whisky, rum, gin, are all made by distillation from fermented liquors and they sometimes contain as high as fifty per cent of alcohol. Some wines not distilled are made stronger by having alcohol or distilled liquors added to them. Compare proportions in Fig. 6.

Whether one drinks fermented liquors or distilled ones that have been diluted to about the same proportion of alcohol matters little. It is the alcohol that is the chief source of danger. When the craving becomes so imperative that the stronger liquors are called for, the poisonous effects of the alcohol on various parts of the body make the course of destruction more rapid.

In a book on hygiene, entitled "How to Keep Well," Professor Crandall makes the following statement: —

"Schooling has recently presented statistics in which he shows that the use of wine and spirits in America is small, while the use of beer is not half that of Germany and England. He believes that the alertness and prompt energy of the American may be due in part to this relative abstinence from alcoholic drink."

Dr. Rudolph Wlassak, of Vienna, writes: "The long-harbored expectation that an increased use of beer would bring about a corresponding decrease in the usual and favorite kinds of whisky has not been fulfilled, and even the small amount of alcohol in beer is fully made up by the increase in the amount drunk."

Dr. Claus Harlow, of Berlin, states: "The drink which is of most importance to the tourist is water. All other drinks are only useful as substitutes where water cannot be obtained. Beer is the worst foe of the sportsman. Particularly on hot summer days, its action is directly depressing and stupefying. The muscles become feeble, the brain heavy, headache sets in, and all energy is gone. Wine is not much better than beer."

CHAPTER VI

DIGESTION

Digestion. — The object of digestion is to dissolve and to change the food we eat so that it may be absorbed by the body. Scarcely any of the foods are immediately available for the wants of the system in the form in which we take them. They must be changed, and this change is brought about by the action of certain liquids or juices found in the body known as the **digestive juices.** These juices, also called **secretions**, are derived from certain glands which are called **secretory glands.** All the secretions are the direct result of the activity of the cells of the secretory glands.

Excretion. — As the body works, its cells wear out or break down. This old or worn-out material must be removed from the body. We all know how the wick of the lamp must be trimmed and how the candle must be snuffed, if the flame is to burn brightly. We must remove the ashes from the stove or the furnace in order to make the fire burn well. It is much the same with our bodies, in which, as we have learned, the food is burned, or more properly, oxidized. These waste products of that oxidation must be removed from the body. There are certain glands or organs set apart for the particular work of removing these broken-down and worn-out materials; these are called the **excretory organs**, and the waste which they enable the body to throw off is called an **excretion.**

We have, therefore, two great problems to study: How nourishment is supplied to the body, and how waste is removed from the body.

The Alimentary Canal. — It is in this canal that the process of digestion occurs. Beginning at the mouth, the alimentary canal extends through the body. In the adult, it would, if uncoiled, be about thirty feet in length and it is lined through its entire length by a soft, velvety tissue called the **mucous membrane.** In this membrane are minute glands, some of which secrete mucus, while others secrete some of the several digestive juices. Named from above downward, there are the following parts: the mouth, pharynx, œsophagus, stomach, small intestine, and large intestine. A study of Fig. 7 will aid in understanding the location and form of these several parts.

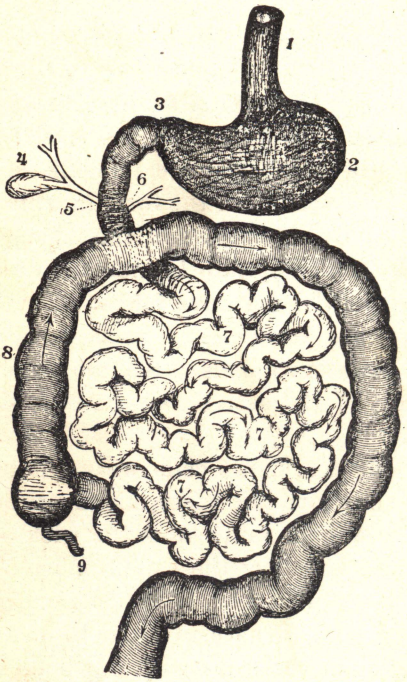


FIG. 7. — The alimentary canal: (1) the œsophagus; (2) the stomach; (3) the pylorus; (4) the gall bladder; (5) the duct carrying bile to the intestine; (6) the duct from the pancreas; (7) the small intestine; (8) the large intestine; (9) the appendix.

The **pharynx** starts at the back of the nasal passage and extends about four and one half inches down the neck, where it becomes continuous with the œsophagus.

The **œsophagus**, see Fig. 7 (1), is about nine inches in length, and extends from the pharynx to the stomach. The **stomach** (2) is the most dilated portion of the canal. It lies transversely in the **abdominal cavity** (which also holds the liver, intestines, kidneys, and other organs not concerned with digestion), and is connected below with the **small intestine** (7). The small intestine is about twenty feet in length, and terminates in the **large intestine** (8), which is about five feet in length. It will be noticed that the small intestine occupies the center of the abdominal cavity, while the large intestine passes around the borders of the cavity. All of Fig. 7, except (1), represents that part of the alimentary canal situated in the abdominal cavity.

The Peritoneum. — Nearly all the abdominal cavity is occupied by the organs of digestion. Lining this cavity, and covering more or less perfectly all these organs, is a thin, delicate membrane, called the peritoneum.

The Appendix. — The vermiform appendix is a tube about the size of a slate pencil and three or four inches in length. It is situated on the right of the lower part of the abdominal cavity. The appendix opens from the large intestine at the point where the small intestine joins it. At the further end it is closed and it floats in the abdominal cavity. Its purpose in the body is not understood, and scientists have reached the conclusion that it is not now of use, but is a curious remainder from some organ that was once, perhaps in prehistoric times, active in the human body. As it opens from the large intestine, some of the waste matter there may enter it. Inflammation is sometimes set up, giving rise to the disease known as appendicitis. Surgeons frequently operate for this disease, entirely removing the appendix. This

operation is considered one of the great achievements of modern surgery.

Mastication. — Mastication, or chewing, consists in cutting and grinding the food by the teeth. It is purely a mechanical process, yet it is necessary in order that the food may be better prepared for the action of the digestive juices; the finer the particles of food are, so much the better can these juices act upon them.

One very important result accompanying mastication is the thorough mixing of the food with the saliva. As a result of this, the food is moistened and prepared for swallowing, while at the same time some of its starchy elements are changed into sugar. The solid and semi-solid foods should be chewed very fine. One of the most common causes of stomach trouble is incomplete mastication, a result of too rapid eating. Let no food pass down the throat that is not finely chewed.

Form and Function of Teeth in Animals. — As the habits and foods of animals differ, so do their teeth vary in form and function, in order best to serve particular needs. Fishes and serpents, that swallow their food entire, have no need for any cutting or grinding teeth. The function of the teeth in these animals is restricted to seizing and holding the food. Therefore their teeth are sharp and curved, with the points set backward, so that when once the prey is caught it is very difficult for it to escape. In the horse and allied animals there are two kinds of teeth, — those in front, the incisors, for cutting off the herbage; and those farther back, the molars, for grinding. Compare Figs. 8 and 9.

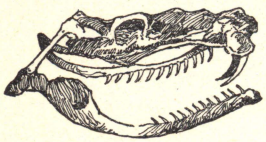


FIG. 8. — The skull of a snake.

In the gnawing animals, as the rats, mice, and squirrels,

the incisor teeth are remarkably developed. Their edges are sharp and chisel-shaped, and they are directly opposed to each other in the upper and lower jaws. They are peculiar also in their growth. As the ends are worn away, the teeth are pushed up from their roots, thus keeping their normal length. Sometimes one of these animals has one of its incisor teeth broken off, or injured so that it fails to grow. The corresponding tooth in the other jaw then has no tooth against which to cut, and hence it is not worn away. It keeps on growing, occasionally to such a length that it prevents the animal from getting its food, and thereby causes its death.

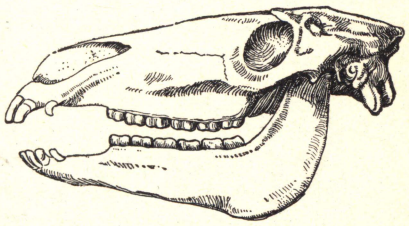


FIG. 9. — The skull of a horse.

Development and Growth of Teeth in Man. — In man, the teeth are at first masses of soft tissue within the jawbones. They gradually assume their characteristic shapes, and are fully formed before they appear through the gums. They are not capable of self-repair; neither do they grow nor change in shape after they are once formed. As already explained, the teeth are most important aids to digestion.

Two Sets of Teeth. — The jaws of a child are not so large as those of an adult, hence they cannot hold as many teeth. To compensate for this, there are two sets of teeth. The teeth of the first set are called the **temporary** teeth, and the teeth of the second set are called the **permanent** teeth.

The first teeth of the temporary set appear about the sixth or seventh month; they come one by one, until the whole set of ten for each jaw is complete by the end of

the second year. In the fifth or sixth year, the temporary teeth begin to loosen and are removed, and the permanent teeth begin to appear. At twelve or thirteen years of age, the full set of permanent teeth is present, except the wisdom teeth. These usually do not appear until the person is twenty or twenty-five years of age. The permanent teeth are thirty-two in number, sixteen for each jaw. See Fig. 11. They are fully developed in the jawbones, beneath the temporary teeth, before they appear.

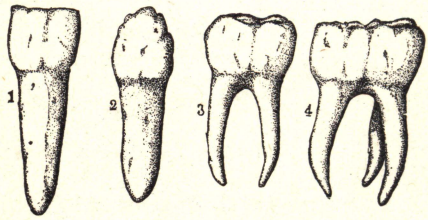


FIG. 10 *a*. — The teeth of an adult: (1) an incisor, or cutting tooth; (2) a canine, or eyetooth; (3) molar of the lower jaw; (4) molar of the upper jaw. FIG. 10 *b*. — Section of a tooth.

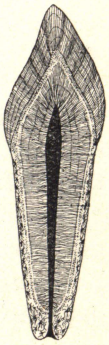


FIG. 10 *b*.

The Structure of Teeth. — Each tooth consists of the crown, or the part projecting into the mouth ; the neck, or the part surrounded by the gums ; and the root, or the part deeply seated in a bony socket. When broken open, a tooth is seen to be hollow. Fig. 10 *b*, a section of the incisor, illustrates the shape of this central cavity, showing how it conforms to the general outline of the tooth, and thus varies in form for the several teeth. In the living tooth, this cavity is filled with nerves and blood vessels, which are held together by a delicate connective tissue. This is called the pulp of the tooth. When inflamed, it gives rise to a most intense toothache.

Surrounding the crown of the tooth is the hardest substance in the body, called the **enamel**; around the root is a thin layer of bone, called **cement**; but the greater part of the tooth consists of a hard substance, called **dentine**, or ivory. The dentine surrounds the pulp cavity and extends outward to the enamel and cement:

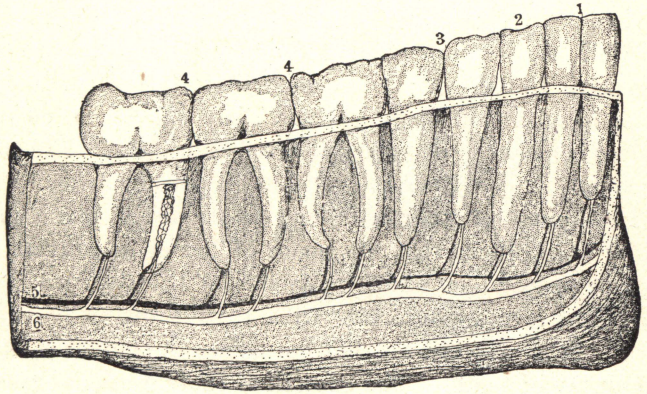


FIG. 11. — A side view of the lower jaw with the outer walls of bone removed, showing the teeth in proper place: (1) the two incisors; (2) the canine; (3) the two bicuspids; (4) the three lower molars (the last molar is sometimes called the wisdom tooth); (5) a blood vessel; (6) a nerve.

in structure it is like the tusk of the elephant, harder than bone, but not so hard as the enamel.

The figure shows that a tooth is pierced with innumerable fine canals that extend from the pulp to the very outside edge of the dentine. These canals are filled with fibers of living matter which are connected with the cells of the pulp. With the exception of the enamel, therefore, a tooth is a living tissue, having nerves and blood vessels in its center, bone cells in the cement around its roots, and innumerable fibers of tissue pene-

trating the dentine. With this knowledge, it no longer seems strange that decay should make the teeth ache, and that extracting them should cause pain. Yet with all this living matter entering into their structure, the teeth cannot repair themselves when injured. They should receive the best of care.

Care of the Teeth. — The necessity of having good teeth in order to present an attractive personal appearance, as well as the important relation of the teeth to the digestive function, is so evident that it is surprising so little attention is given them. They should be cleaned at least once each day; better after each meal. Use some pure dentifrice, either in liquid or in powder form.

The Decay of Teeth. — Some teeth decay much more easily than others that are made of better substance. A lack of proper food and poor health at the time when the teeth are forming interfere with their growing hard and firm. It is now known that germs are the actual cause of the decay of teeth. The growth of these germs is greatly aided by the natural moisture and warmth of the mouth, and also by the presence of particles of food that may carelessly be left around the teeth after eating. A dentist should be consulted as soon as a tooth gives pain, or if a cavity is discovered, in order that the trouble may be remedied before the tooth structure is seriously damaged. To prevent decay and to preserve the teeth, keep them clean. Some persons give the best of attention to their teeth when they are well, but absolutely neglect them when ill. In this way the teeth are often badly injured. During illness the secretions of the mouth are often bad and so the teeth need extra care at such a time.

The Saliva. — The saliva is a fluid which flows into the mouth mainly from three pairs of glands, called the

salivary glands, situated three on each side of the mouth. Mixed with the saliva is some mucus from the mucous glands found in the lining membrane of the mouth. One pair of the salivary glands, the **submaxillary** glands, is situated in the floor of the mouth between the two sides of the lower jawbone. Another pair, the **sublingual glands**, is situated beneath the tongue. The secretions of these glands are conveyed through little ducts which open into the mouth just beneath the tongue. The third pair of glands, the **parotid**, is situated a little below and directly in front of the ears. When inflamed, these glands become swollen and painful, as in the disease known as "mumps." This inflammation is due to a germ. The germs may be carried from one who is ill with the disease to some one else who has not yet had it, giving him the disease. Hence we say that it is contagious.

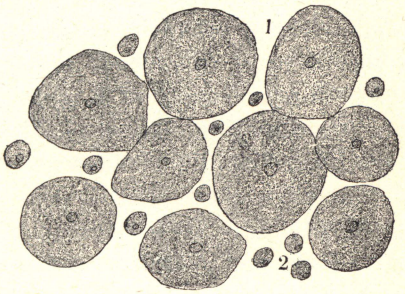


FIG. 12. — Cells found in the saliva, magnified: (1) epithelial cells from the mucous membrane lining the mouth; (2) lymph corpuscles that have escaped from the lymphatics of the mouth.

A drop of the saliva examined under the microscope shows a number of old cells that have fallen from the lining membrane of the mouth. The vast number of these cells always found in the saliva gives another striking proof that the body is rapidly and continuously changing; for new cells must take the place of the old, as fast as the latter are removed. Fig. 12 illustrates these old cells together with others which have escaped from the lymphatic vessels, called lymph corpuscles.

Uses of Saliva. — The saliva is a constant secretion, although it can be greatly increased by the movements of the jaws, especially when food is being masticated. It is essential in order to keep the tissues about the mouth and the throat moist. If the mouth is dry, speaking is extremely difficult, as many a young orator knows when the nervousness caused by a first appearance in public temporarily checks the secretion of saliva.

The principal function of the saliva is to moisten the food, and thus aid in its mastication and solution ; for it is very difficult to swallow anything that is hard and dry, unless first moistened with some fluid. By dissolving certain substances the saliva enables us to taste them ; for solid bodies cannot be tasted. A chemical examination of the saliva shows that it contains a peculiar substance called **ptyalin**. It is this ingredient which gives the saliva its power to change starch into sugar ; but, owing to the short time the food is kept in the mouth, only a small amount of the starchy foods is thus changed. We shall learn later that this important change occurs principally after they leave the stomach.

As one object of the saliva is to furnish moisture, so that the food may be more readily swallowed, it follows that it is not necessary to wash down the food with large quantities of some fluid ; indeed, it is much better that the food should be mixed with the saliva than with any other liquid. As a rule, the saliva furnishes moisture enough, as from one to three pints are secreted each day. While there is no harm in using a moderate amount of water with our meals, yet large quantities are certainly injurious, especially if the liquids are either very hot or very cold.

Promiscuous Spitting. — Spitting in public places is not only an exhibition of bad manners, but it is a menace to

the public health. It is a fact that in the mouth of persons who are apparently in good health, the germs of such diseases as diphtheria, pneumonia, and consumption are frequently found. These persons may never contract any of these diseases, for the vigorous, healthy body can resist many germs; but other persons may not have so much of this resistive power, and should these germs once reach them, they might not be able to withstand the attack. Let us see how easily these germs may pass from one person to another. When secretions from the throat and mouth are deposited in public places, they soon become dry and are easily crushed to a powder, which floats in the dust of the atmosphere. In this condition these germs may be inhaled by those who are in fairly good health and may be the direct cause of producing disease. Therefore, spitting in public places is now declared a nuisance in many of the large cities, and is strictly forbidden by law; one who indulges in it is liable to punishment by fine, by imprisonment, or by both.

The Pharynx. — The **pharynx** is partly divided from the mouth by a curtain hanging down from above, called the **soft palate.** It is thus named to distinguish it from the **hard palate,** which forms the roof of the mouth. From the center of the soft palate, there is a prolongation downward, the **uvula,** often incorrectly called the palate. In the upper part of the pharynx, on a line with the floor of the nasal passages, are the openings of two tubes, called the Eustachian tubes. Each tube extends from the side of the upper part of the pharynx to the middle ear. The openings of these tubes cannot be seen by looking into the throat, because they are behind the soft palate.

The Tonsils. — On each side of the throat, below the soft palate, is a small round body called the **tonsil.** The tonsils

are sometimes permanently enlarged. If the enlargement is sufficient to interfere with speech or with the swallowing of food, a physician should be consulted about removing them. When a severe inflammation of the tonsils occurs, it is known as tonsilitis.

Deglutition or Swallowing. — After the food has been masticated, it is forced to the back of the mouth by the tongue and other parts of the mouth and it passes into the pharynx. The muscular walls of the pharynx and œsophagus continue to contract just behind the food, thereby pushing it into the stomach. Thus swallowing is a muscular act. This accounts for the fact that the horse and many other animals can drink with the mouth held below the throat; that is, when they drink the water runs up hill, because it is pushed up.

As the food passes down the pharynx, it is prevented from entering the windpipe by a lid called the **epiglottis**, which shuts tightly down upon the windpipe and over it the food passes. Occasionally a small amount of food or drink gets into the air passages, causing violent coughing.

The time that elapses from the beginning of deglutition until the food reaches the stomach is not more than one tenth of a second.

CHAPTER VII

DIGESTION IN THE STOMACH AND THE INTESTINE

The Stomach. — The **stomach** is between the œsophagus above and the small intestine below, and is situated in the left upper side of the abdominal cavity. It is the principal organ of digestion. In the adult it is capable, when moderately distended, of holding about three pints. The capacity of the stomach of a new-born child is about one ounce. The left side of the stomach is called the **cardiac portion**, so named because it is the part nearer the heart. The right side is called the **pyloric portion**, so named from a Greek word meaning "gate-keeper." The food enters the stomach through the œsophagus at the cardiac end, and leaves it at the pyloric end, which is at the left of Fig. 13.

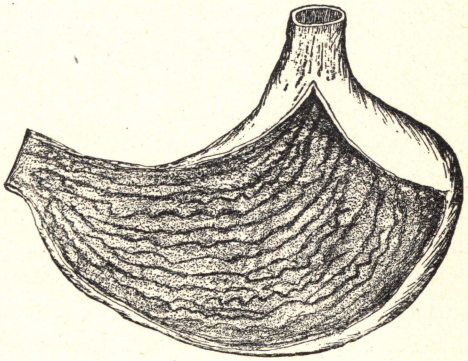


FIG. 13. — View of the inside of the stomach. The front walls have been cut away, showing the mucous lining arranged in folds or plaits.

The Pyloric Opening. — The opening through which the food must pass from the stomach to the small intestine is called the **pyloric opening**. It is well guarded by a valve.

During the early stages of digestion this valve remains closed in order that there may be time for certain foods to be acted upon by the gastric juice. As digestion proceeds, the valve opens now and then for the escape of the food; later, towards the close of digestion, it is open nearly all the time.

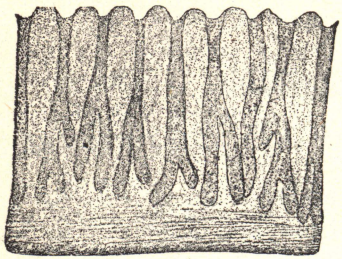


FIG. 14. — A cross-section of a small portion of the walls of the stomach, slightly magnified, showing the glands.

The Gastric Glands. — In the mucous membrane of the stomach are found vast numbers of minute glands, called the gastric glands. These are of the nature of tubes, or canals, lined with cells which secrete a juice called the **gastric juice.** Whenever food is taken, this juice is poured into the stomach through the openings of the glands.

Fig. 14 illustrates a section of a small portion of the walls of the stomach. If this section were viewed from above, the minute depressions would appear as circular openings; they are the openings of the glands. Fig. 15 illustrates some of these glands magnified, and Fig. 16 shows one of the glands very highly magnified. A careful examination of this figure shows two kinds of cells in the lower part.

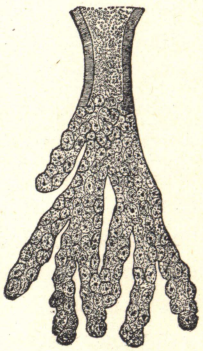


FIG. 15. — Glands of the stomach, as seen with a microscope.

The Gastric Juice. — The gastric juice is clear and colorless, in this respect resembling water. But it contains two marked ingredients not found in water; these

are **pepsin** and an acid called **hydrochloric acid.** It is now known that there are some cells in the gastric glands that secrete the pepsin, while other cells secrete the acid.

When the stomach is empty and its mucous membrane thrown into folds, the membrane is of a pale red color, and there is no secretion of the gastric juice. Upon the introduction of food, the mucous membrane rapidly fills with blood, becomes bright red in color, and secretes the gastric juice in abundance. Not all foods are digested in the stomach by the gastric juice; the oily and starchy foods pass out of it unchanged.

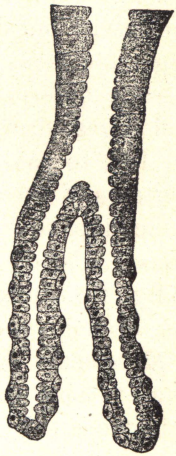


FIG. 16. — A gland of the stomach, highly magnified.

The chief characteristic of the gastric juice is its power to dissolve and digest the proteids in foods. If only the proper amount of these be taken, they are completely digested in the stomach; but if more be taken than can be digested by the gastric juice, they pass out into the intestine, where the work is completed by the pancreatic juice. We shall learn that the pancreatic juice possesses the same power to digest proteids as the gastric juice. It is estimated that the stomach of a healthy adult secretes from ten to twenty pints of gastric juice each day.

Action of Gastric Juice on Different Foods. — As has been stated, the proteid foods, such as the lean meats, the white of egg, etc., are digested in the stomach. The gluten in bread is liquefied and digested in the stomach, but the starch in it is unaffected. Fatty foods, as the fat of flesh, are acted upon but slightly by the gastric juice, and

only in this way, — the gastric juice liquefies the tissue that surrounds the fat globules, thus allowing the fat to escape in the form of oil drops. But upon the fat itself the gastric juice has no effect ; the fat passes out of the stomach unchanged. Milk is coagulated, or curdled, soon after it reaches the stomach. This change is now believed to be due to the action of a distinct ferment that exists in the stomach. Whatever the cause, a curd is formed, and this curd is called **casein**. The gastric juice digests the casein, but does not affect the oil drops, or fat. The vegetable foods are digested in a manner similar to that already described. The albuminous parts are dissolved and digested, while the oily and starchy ingredients are set free to pass out of the stomach unchanged. As the contents of the stomach begin to pass through the pyloric orifice into the intestine, they consist of digested albuminous foods, of undigested starch, and fat, and of much indigestible material. To this mixture the name **chyme** has been given.

Movements of the Stomach. — As soon as the food reaches the stomach and the secretion of the gastric juice commences, the muscular walls of the stomach begin to contract. These contractions produce such a movement of the contents of the stomach that the food and gastric juice are thoroughly mixed. The food is thus carried back and forth, to every part of the stomach, so that the whole mass may be penetrated thoroughly by the gastric juice, and digestion go on simultaneously in all parts.

Conditions affecting Digestion. — The solid foods are more easily digested if the pieces be minutely divided ; therefore when large pieces of food are swallowed, digestion is retarded. Food should be eaten slowly, that the gastric juice may be formed in sufficient quantity to be

thoroughly mixed with it as it is swallowed. If the food be eaten slowly, there is but little danger of overloading the stomach, but rapid eating is quite likely to result in overeating, which leads to many troubles.

The following table (h = hours; m = minutes) will give a fairly correct idea of the average time required for the digestion of several different foods, including those digested in the stomach and those which undergo this process farther down the alimentary canal.

Easy of Digestion	h m	More Difficult	h m
Rice, boiled	1 00	Potatoes, boiled	3 30
Apples, sweet, raw	1 30	Oysters, fried	3 30
Milk	2 00	Eggs, hard boiled	3 30
Cabbage, raw	2 00	Bread, fresh	3 30
Oysters, raw	2 30	Pork, broiled	3 30
Potatoes, baked	2 30	Veal, roasted	3 30
Lamb, broiled	2 30	Beef, fried	4 00
Chicken, boiled	2 45	Veal, fried	4 00
Eggs, soft boiled	3 00	Cheese	4 00
Custard, baked	3 00	Cabbage, boiled	4 30
Beef, broiled	3 00	Duck, wild, roasted	4 30
Mutton, broiled	3 00	Pork, fried	4 30
Beef, roasted	3 00	Pork, roasted	5 15

In the case of the average meal, with its variety of foods, a healthy person would usually complete digestion in between three and four hours.

Drinking hastily a glass of very cold water might be sufficient to drive the blood from the mucous membrane of the stomach and check the action of the glands. It might require some time for them to recover from the shock of the cold, during which but little, if any, gastric juice would be secreted. This delay would prolong digestion and be quite likely to produce some form of

stomach trouble. Too much liquid with a meal dilutes, and therefore weakens, the gastric juice. It is much better to quench the thirst before going to the table. Mental and physical fatigue will interfere with digestion; therefore one should never eat a hearty meal when very tired, either from manual labor or from severe mental exercise. A short rest of a few moments before going to the table is a wise precaution in such cases. It is also true that tranquillity of temper has much to do with the proper digestion of food.

The Liver. — The **liver** is the largest gland in the body. It is situated in the upper part of the abdominal cavity, just beneath the diaphragm. The greater portion of it is on the right side of the body, although some of it extends over to the left side. A reference to Fig. 39 will give an idea of its location, as well as of its relation to the diaphragm and to the stomach. The microscope shows that the liver consists largely of cells. These cells secrete a fluid, called **bile**, or **gall**. The liver is constantly secreting this bile. During the intervals of digestion, the bile collects in a sac, situated on the under side of the liver and called the **gall bladder**. The bile may pass directly from the liver into the intestine through a duct, shown in Fig. 17, at (7), or it may first collect in the gall bladder and pass into the intestine through another duct, at (8). These two ducts, however, unite into one, at (9), forming one large bile duct. Just before this duct opens into the intestine, it unites with the duct from the pancreas, and the two terminate in a common opening, as shown at (10).

The Bile. — From two to three pints of **bile** are secreted each day. Many experiments have proved that if this secretion be prevented from entering the intestine, or if

the liver should fail to produce it, sickness and death will follow. When the ducts leading from the liver to the intestine become stopped up in any way, so that the bile is held back, the blood vessels absorb the bile and carry

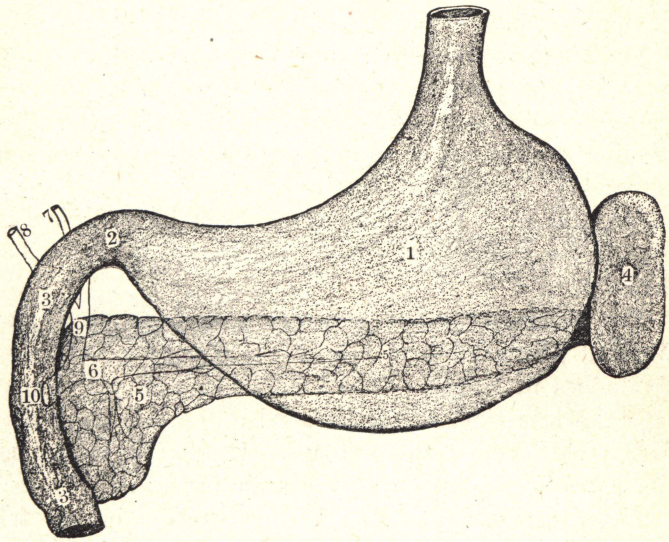


FIG. 17.– A diagram illustrating the position of the pancreas and its relation to surrounding parts: (1) the stomach; (2) the pylorus; (3) the small intestine; (4) the spleen; (5) the pancreas; (6) the duct of the pancreas: (7) the bile duct from the liver; (8) the bile duct from the gall bladder; (9) the common bile duct, formed by a union of the two bile ducts. The common bile duct unites with the pancreatic duct, and the one duct thus formed opens into the small intestine at 10.

it to all parts of the body. This makes the skin yellow, as in cases of jaundice. The bile aids in the digestion and absorption of the oily and fatty foods. It moistens the walls of the intestine and renders their contents more liquid. It also does much to prevent the decomposition of food while it is in the intestinal canal.

The bile has another very important function; it acts

as a natural laxative. A diminished secretion of bile produces constipation, while an excessive secretion causes bilious diarrhea. The term "biliousness" is quite misleading, but it generally relates to either one or the other of the above conditions.

The Liver Sugar. — We know that all the starchy foods must be changed into sugar before they can be absorbed; therefore all the starch and sugar taken into the body are finally absorbed as so much grape sugar. This sugar is carried directly to the liver, where it undergoes a slight change. The liver stores it in its cells, only to give it up again to the blood as the needs of the body demand.

The Pancreas. — The **pancreas** is a long, thin gland situated just below and behind the stomach; it is about six inches in length. The duct from this gland opens into the intestine, in common with the bile duct, about four inches below the pylorus. In the lower animals, the pancreas is known as the sweetbread.

The **pancreatic juice** has a direct action on all fatty and oily foods. It is the only digestive juice that is able to completely digest the fats and prepare them for absorption. It changes them into a white, opaque liquid called **chyle**. When examined with the microscope, chyle is found to consist of extremely minute particles of fat or oil. When any fat or oil is thus changed, it is called an **emulsion**. All fats must be turned into an emulsion before they can be absorbed. The pancreatic juice is also capable of changing the starches into sugar, completing the work which was begun by the saliva, and also of digesting proteid foods, although this is principally done in the stomach.

Contraction of the Intestines. — By the contraction of the walls of the stomach the food is forced into the small

intestine; and by the contraction of the walls of the intestine, the food is still further moved along the alimentary canal, where it mingles with other digestive juices and is more or less absorbed. In health we are not conscious of these movements, but if, because of any unusual conditions, they become more rapid, or more strong than usual, they give rise to griping and to severe pains.

The Intestinal Juice. — Situated in the mucous membrane of the small intestine are minute glands; these secrete a digestive fluid, called the **intestinal juice.** It aids in the digestion of the foods, principally of the starches and the fats.

Effects of Alcohol on the Stomach. — When wine, whisky, beer, or any other alcoholic liquor comes into contact with the mucous membrane of the stomach, it causes an increased flow of blood there. Irritated by the presence of the alcohol, the glands throw out an extra quantity of gastric juice. On this account alcohol is considered by some an aid to digestion, but physiologists who have studied the matter say that the presence of the food itself should be a sufficient stimulus, and that the overwork thus thrown upon the glands by the alcohol soon weakens them so that they throw out an imperfect juice. The mucous membrane becomes constantly red or inflamed, later the glands become smaller, and permanent indigestion results.

Such an inflamed condition of the stomach is called gastric catarrh. The inflammation causes an unnatural heat in the stomach, together with a sickening, faint feeling. To quiet the burning sensation and to quench its accompanying thirst, more liquor is taken. This appears to give relief; but the relief is of a most decep-

tive kind. The alcohol simply deadens for a short time the nerves of the stomach. The apparent temporary relief is to the drinker a sufficient excuse for his continuing its use. Again and again is this experiment repeated, while the inflamed stomach remains a witness to the folly of trying to put out a fire by continually adding more fuel. Persons thus addicted to the use of alcoholic drinks many times make earnest effort to do without them ; but the craving of the inflamed stomach,

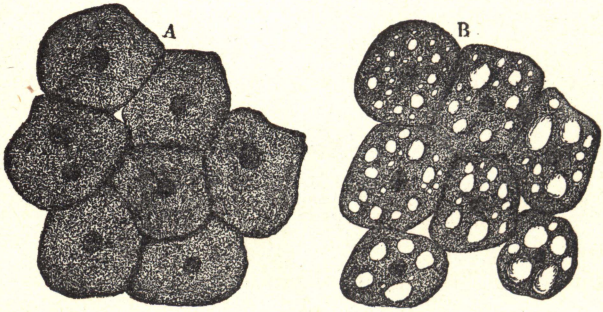


FIG. 18. — A, liver cells, highly magnified, from a healthy liver. B, liver cells, highly magnified, from a fatty liver, the oil globules take the place of healthy liver substance.

the unnatural thirst, and the strong appetite, all appeal for more drink.

Effect on the Liver. — The secretion of bile and the storing up of the liver sugar can only be carried on properly in a healthy liver. Each cell must be ready to do its part. When drinks containing alcohol are taken, the blood vessels carry the alcohol directly to the liver, frequently causing that gland to become large and fatty. In these cases the microscope shows that each cell has become filled with minute globules of fat. Such a condition is represented in Fig. 18, at B. These fat globules

cannot make bile, neither can they store up the liver sugar; therefore the liver becomes a mass of fatty tissue, unable to do its work.

After the long-continued use of alcoholic beverages, especially whisky, brandy, and gin, the liver undergoes other changes. It becomes greatly reduced in size and much too hard. Such a liver is so characteristic of alcohol poisoning that medical authorities have given it the distinct name of the "drunkard's liver." The microscope shows the cells of such a liver to be much reduced in size, and otherwise changed in appearance.

When the liver cannot perform its functions properly, the health of the whole body will, sooner or later, become seriously affected. Alcohol does not interfere simply with the functions of the liver, but it strikes deeper, and actually changes the very structure of that important organ.

Effects of Tobacco on Digestion. — Digestion is often impaired in those who use tobacco. By chewing tobacco, the salivary glands are constantly overworked, so that when the saliva is most needed, at mealtime, an insufficient amount is furnished. This necessitates the use of some other liquid to moisten the food; therefore an excessive amount of water, tea, or coffee is used. The more general effects are of a secondary nature. The nicotine is absorbed in sufficient amount to affect the nervous system, giving rise to a kind of indigestion called nervous dyspepsia.

CHAPTER VIII

ABSORPTION

Definition of Absorption. — It has been stated in a previous chapter that the insoluble starchy foods are changed into the soluble grape sugar, by the saliva and the pancreatic juice; that the lean meats, eggs, and other albuminous foods are digested by the gastric juice, and that the fats are changed by the pancreatic juice. If our foods could be absorbed in their natural state, this complicated work of digestion would be unnecessary. But we know that the foods must first be liquefied and changed, before they can be taken up by the proper vessels and carried to the various parts of the body.

Absorption, therefore, is the process by which the digested food passes from the alimentary canal into the blood vessels and the lymph vessels.

Absorption from the Stomach. — The water that is taken as drink, and also that found in the food, is not to any great extent absorbed from the stomach, but passes, after a short time, into the intestines. There is a slight absorption, from the stomach, of sugar and of the changed albuminous foods; but the process of absorption takes place principally in the intestines.

Structure of the Small Intestine. — The outer walls of the small intestine are composed of involuntary muscle, which is directly continuous with that forming the walls of the stomach. Within this muscular wall, and attached

to it, is a mucous membrane which lines the whole of the small intestine. This mucous membrane is arranged in folds, or plaits, which pass around and transversely to the canal. Some of the folds are nearly two thirds of an inch in depth at their broadest part, though most of them are smaller. These folds retard the passage of food along

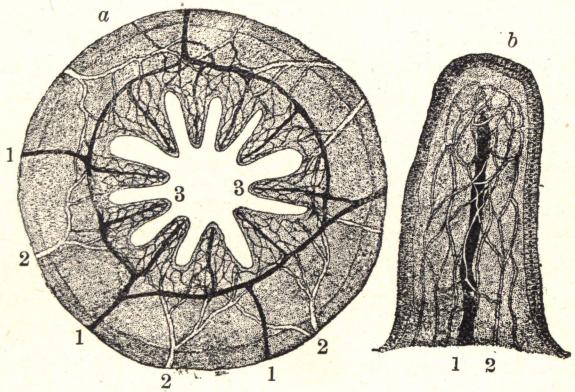


FIG. 19 *a*. — Diagram of a cross section of the small intestine : (1) lacteal or lymphatic vessels ; (2) blood vessels ; (3) villi.

FIG. 19 *b*. — A villus of the small intestine, magnified : (1) central lymphatic ; (2) blood vessels.

the intestine, and also increase the surface for absorption. Projecting from these folds, and covering their inner surfaces, are very minute elevations, called **villi**. They are from $\frac{1}{30}$ to $\frac{1}{50}$ of an inch in length and they hang down toward the center of the canal like so many minute fingers. They give to the mucous membrane its velvety appearance. It is estimated that there are fifteen or twenty million of these villi in the small intestine.

Fig. 19 *a* illustrates the general arrangement of the various parts as seen in a cross section of the small intestine. The outer wall is thick and firm, composed of strong mus-

cular tissue. Within this are represented the villi, hanging down toward the center of the canal. Two kinds of vessels are illustrated in the drawing, — the **blood vessels** and the **lymph vessels**; the latter are also known as the **lymphatics**, or the **lacteals** (from the Latin word *lac*, "milk"), because when found in the villi they look white.

A careful study of one of these villi is necessary for a clear understanding of the subject of absorption. At Fig. 19 *b* is a single villus, highly magnified. Each of those represented in Fig. 19 *a* would appear the same under an equally high magnifying power; in fact, this single villus may be taken as a representative of the twenty million found in the body. Each villus is surrounded with a layer of minute cells. Directly in the center (1) is a darkly shaded vessel; this is the **lacteal**, or lymphatic vessel. It begins at the free end of the villus and unites with the lacteals from the other villi, as clearly seen in Fig. 19 *a*. Surrounding the central lymphatic are numerous capillary blood vessels. A reference to Fig. 19 *a* shows that the capillaries from several villi unite to make the larger blood vessels, at (2). The villi, therefore, consist of two kinds of vessels, surrounded by a layer of cells.

Absorption from the Small Intestine. — The central lymphatics, or lacteals, of the villi are especially concerned in the absorption of the digested fatty foods. The blood vessels of the villi absorb the other digested foods, as grape sugar and the albuminous foods. This is the general rule, although it is a fact that each system of vessels may absorb all kinds of digested food. Water and many watery solutions are freely absorbed while in the small intestine.

Absorption from the Large Intestine. — From the fact that there are no villi in the large intestine, we conclude

that the absorption of digested foods was largely completed in the small intestine. Yet, without doubt, any foods which may have escaped absorption in the small intestine may be absorbed while in the large intestine. But the principal work of absorption in the large intestine is confined to the absorption of water. The contents pass through the large intestine very slowly, the average time required for the passage being in the vicinity of twelve hours.

The Portal Vein. — The blood vessels of the villi unite with other blood vessels from the stomach to make a large vein, called the **portal vein**. This vein goes directly from the stomach and the intestine to the liver. It carries the digested foods, taken up by the blood vessels, to the liver. At the proper time, this food will pass from the liver through certain veins, directly to the heart. From this central point, it is soon sent out to all parts of the body.

Lymphatic Vessels and Glands. — The lymphatic vessels may be well compared to the veins, for they begin as minute capillaries which become larger and larger until they approach the heart. All along the course of the lymphatic vessels are great numbers of round bodies varying in size from a mustard seed to a bean. These are the lymphatic glands. Many of the lymph vessels pass directly through these glands on their way to the heart.

The Lymph. — The watery part of the blood is constantly passing through the thin walls of the blood capillaries. Being then outside of the blood vessels, it is no longer called a part of the blood, but is given the name of **lymph**. It keeps the delicate cells in a moist condition and is an aid to the proper performance of the mysterious processes of nutrition. When this liquid first escapes from the capillaries, it is rich in nourishment. The cells,

however, take from it just those elements necessary for their proper nourishment and growth, and it thus loses its most nourishing ingredients. At the same time that the cells are taking up the nourishment from this lymph, they are also giving back to it their worn-out and useless material. Each cell takes its new food and gives off its waste material.

It is the general object of the lymph vessels to collect this used-up lymph and bring it back to the blood. Although we have seen that the lymph is not at first confined to the walls of any vessel, yet it soon enters the openings of minute lymph capillaries, and these soon become the large lymph vessels which at last enter the veins near the heart. Thus we learn that the flow of lymph is always in the direction toward the heart.

The Thoracic Duct. — Directly in front of the spinal column lies a tube called the thoracic duct. It is from eighteen to twenty inches in length, in the adult, and is about the size of an ordinary slate pencil. This duct carries the greater part of all the lymph and chyle into the blood; it is the central, large vessel for all the lymphatics of the body. There are numerous valves throughout its entire length, so arranged that they completely prevent the lymph and chyle from falling toward its lower part. The duct begins in the lower part of the abdominal cavity by a triangular enlargement, and then passes up through the diaphragm. When near the heart, it makes a sharp curve and empties into a large vein beneath the left collar bone. This vein carries the lymph directly to the right side of the heart. Thus the lymph enters the general circulation.

The lymph from the upper part of the right side of the body reaches the circulation through another lymphatic

duct of small size. It empties into a corresponding vein beneath the right collar bone.

After a meal containing fatty foods, the lymph in the thoracic duct changes from a clear, watery fluid to a milk-white color. This is due to the fact that the lymphatics of the villi take up the digested fats (or chyle), and carry them directly to the thoracic duct. As the digested fats are of a milky color, so the contents of the thoracic duct become of a like color; this only lasts, however, while the chyle is being absorbed. All the other lymphatics are constantly filled with the colorless lymph.

The Lymph Corpuscles. — Before the lymph enters the lymphatic glands it is clear and transparent, and free from corpuscles, but after passing through these glands the microscope shows that it contains a number of small round bodies called lymph corpuscles. Soon these corpuscles mingle with the blood, when they are called the white blood corpuscles. Therefore we see that one source of the origin of the white blood corpuscles is the lymphatic corpuscles.

Review. — Let us now trace the foods from the time they are taken into the mouth until they are absorbed. Take the three representative foods: lean meat, starch, and fat: —

First, **mastication**, or chewing; second, mixing with the saliva; third, swallowing; fourth, **stomach digestion**, for the proteid foods; fifth, **intestinal digestion**, for the fatty and starchy foods; sixth, **absorption**, the proteids and starches in the food being absorbed by the blood vessels, and the fatty foods by the lacteals.

A study of Fig. 20 will aid in understanding and remembering the course pursued by the digested foods.

Begin with the four villi at the right of the intestine:

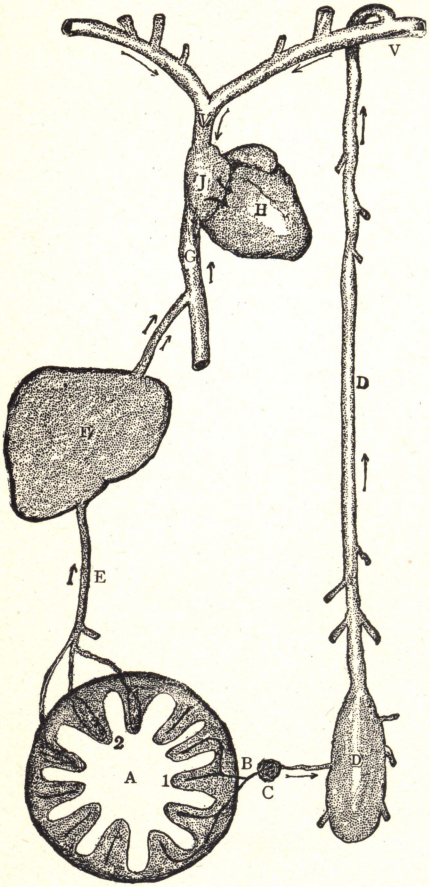


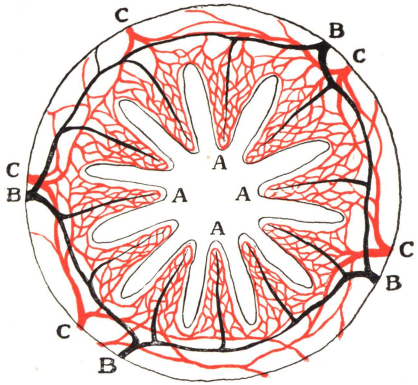
FIG. 20. — Diagram illustrating the course of the absorbed foods. A, intestine: (1) villi with central lacteals; (2) villi with blood vessels. B, lymphatic or lacteal vessels. C, lymphatic gland. D, thoracic duct. E, portal vein. F, liver, at the left of the figure. G, vein. H, heart. J, right auricle of heart. V, vein.

suppose the central lacteals are filled with chyle, or digested fats. The four lacteals unite to form a larger vessel, B, which passes through a lymphatic gland, C, and empties into the dilated beginning of the thoracic duct, D. The chyle then passes up the duct in the direction of the arrowheads, until it enters the large vein, shown in the diagram at V, which leads directly to the right side of the heart. Consult also Plate I, opposite.

Suppose again that the blood vessels of the villi at the left (2) are filled with absorbed foods derived from the lean meats and starches. The vessels soon unite to form the portal vein, E, which carries the food directly to the liver, F. From

PLATE I.—Illustrating the action of the lymphatics: The upper diagram represents a cross section of the small intestine. The finger-like points (A) are the villi. The dark-colored line leading from each one represents a lacteal vessel. These minute vessels unite to make larger vessels as shown at (B). The network of vessels, colored red, represents the capillaries of the villi. These also unite to make larger blood vessels as shown at (C).

The lower diagram illustrates the larger lymphatics or lacteals, of the intestines. The minute lymphatics (dark lines, upper diagram) unite, forming larger vessels and these unite forming still larger vessels, as at 1. These vessels then enter small lymphatic glands (2), and after passing through these glands they terminate in the thoracic duct (3), this duct lies by the side of a larger vein, directly in front of the spinal column. Finally the thoracic duct opens into a large vein beneath the left clavicle.



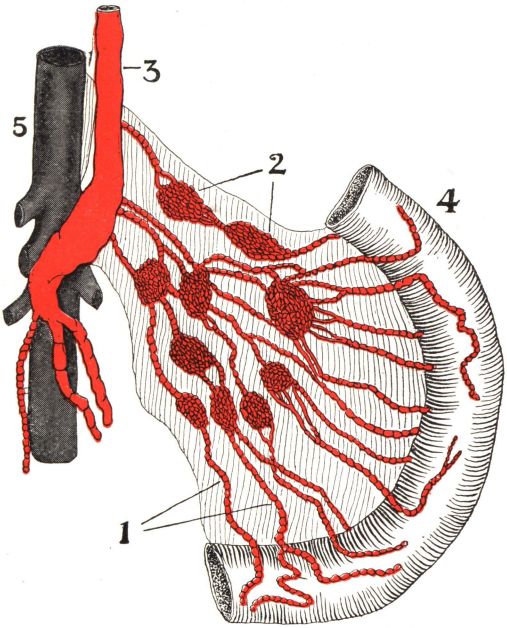


PLATE I.

the liver it can pass through the veins, in the direction of the arrowheads, to the right side of the heart.

Parts of Food not Absorbed. — We have now traced the processes by which the food we eat is absorbed into the blood. We have also learned something of the marvelous way in which the food becomes changed into the various tissues of the body, nourishing them and building them up. But all the food that we eat cannot be so absorbed and changed, for part of it is not digestible, and what is not digested cannot be absorbed.

To illustrate: The walls of the cells of all plants are composed of a substance called cellulose, which is indigestible. Again, there are some tissues in the various meats which are indigestible or are so difficult of digestion that they are frequently not acted upon by the digestive juices. It is also found that we often eat food which contains more nourishment than the body actually requires; in such cases some portion of the food would remain undigested, although under other conditions it might be digested.

Waste must be Removed. — This undigested and waste material must be removed from the body or serious consequences would result. When we are in good health, and pay prompt attention to certain laws of health, nature attends to the carrying off of this waste material. It seems to be a natural law that at least once each day this material must be removed from the body if health is to be maintained. But we frequently overeat, eat too hastily, neglect proper exercise, or in some other way interfere with nature's method. This must always result in affecting the health more or less seriously. If you should ask a physician how important he thought it was to have this waste material removed from the body at least once each

day, he would probably tell you that a great many serious complaints begin from the failure of the body to dispose of this waste material.

In the case of young people it is generally very easy to correct troubles of this kind by proper diet. Fruits are useful as laxatives, and especially such fruits as stewed prunes, figs, baked apples, peaches, and nearly all ripe fruits eaten raw. Eating such coarse foods as brown bread, graham bread, oatmeal, and cracked wheat is also beneficial. Nearly all vegetables, especially spinach, lettuce, cauliflower, and celery will aid nature in the same way. If the suggestions given above do not produce the desired effect then it is better to consult a physician, even before you feel ill, in order that the condition may be easily corrected before it becomes habitual.

The daily removal from the system of useless and waste material, through the action of the bowels, is of such great importance that it is absolutely necessary to good health.

CHAPTER IX

THE BLOOD

Distribution of Blood. — The **blood** is very generally distributed through the body. There are a few parts in which it is not found, as in the hard parts of the teeth, the hair, the nails, the outer layer of the skin, some parts of the eye, and most of the cartilages. These parts are nourished by absorbing the fluids which escape from neighboring blood vessels. It is estimated that about one twelfth of the weight of the body is composed of blood.

Medium of Exchange. — The blood receives a large amount of new material from the digested food, and a supply of oxygen from the air in the lungs. It carries these fresh supplies to the various organs and tissues, gives them up where they are needed, and receives in exchange carbon dioxide and other products of waste. From this it is seen that the blood always contains both new and old material; new material on its way to build up tissue, and old material on its way to the kidneys, the lungs, and the skin through which this worn-out matter is removed from the body.

Composition of the Blood. — Blood appears to the unaided sight as a thick, opaque, red fluid. But under the microscope it is seen to consist of two parts: a transparent, nearly colorless fluid, called the **plasma**; and a large number of minute bodies floating in the plasma, called the **blood corpuscles.**

The Blood Corpuscles. — The blood corpuscles are of two kinds, the white and the red. The **white corpuscles**, as their name indicates, are without color. They are spherical bodies, averaging about $\frac{1}{2500}$ of an inch in diameter. They are a trifle larger than the red corpuscles, but not so abundant, the average number being one white corpuscle to about five hundred red ones, although this number is subject to variation even in health. The white corpuscles are capable of changing their form by a flow of their substance in various directions, after the manner

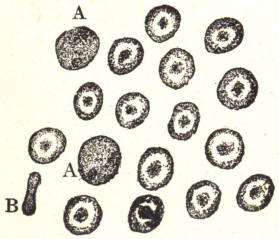


FIG. 21.

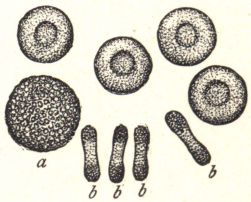


FIG. 22.

FIG. 21. — Human blood, highly magnified: A, the white corpuscles; the others shown are the red corpuscles; B, red corpuscle as seen on the edge. The others are lying flat.

FIG. 22. — Human blood, more highly magnified: *a*, a white corpuscle; the others shown are the red corpuscles; *b*, four red corpuscles as seen on the edge. The others are lying flat.

of the amœba. They originate from the lymph corpuscles.

The white blood corpuscles are known to have a very prominent part in the prevention of disease. It is claimed that these minute bodies are directly concerned in the destruction of germs which gain entrance to the body and which would cause severe diseases unless promptly destroyed. The white corpuscles take these disease germs within their own bodies and destroy them.

The **red corpuscles** of human blood are circular bodies,

slightly hollowed toward the center. Fig. 21 shows a number of these bodies, shaded in the center to give the correct impression that they are concave. One corpuscle, at the left of the figure, B, is seen on the edge, showing that it is biconcave, or slightly hollowed on each side. The red corpuscles exist in vast numbers. It is estimated that in a minute drop of blood there are over five millions of them; while in a medium-sized person there are not less than twenty-five billions, — too vast a number for the mind to comprehend. The red corpuscles originate chiefly from the cells found in the marrow of bone. Fig. 22 represents a few red corpuscles and one white corpuscle, very highly magnified. (Compare the corpuscles in the blood of animals, Figs. 23, 24.)

FIG. 23. — A frog's blood, highly magnified: A, the white corpuscles; B, the nucleated, oval, red corpuscles.

Function of the Red Corpuscles. — The most important ingredient of the red corpuscles is their coloring matter, called **hemoglobin.** This substance has a strong liking, an "affinity," for oxygen. So strong is this affinity that when the blood flows through the lungs, the coloring matter, or hemoglobin, takes oxygen from the air which it finds there. The red corpuscles thus become loaded with oxygen. The blood soon leaves the lungs, and flows to the most distant tissues, which are in great need of this oxygen. But the tissues exert a stronger affinity for the oxygen than does even the hemoglobin, and thus the latter is obliged to give up the oxygen. The red corpuscles are called the "oxygen carriers"; for their great object is to carry oxygen from the lungs to all the various organs and tissues of the body.

Arterial and Venous Blood. — As soon as the red corpuscles receive their fresh supply of oxygen in the lungs, they become bright red in color, making all the blood a bright scarlet. This bright-colored blood is called **arterial** blood. It is found in the arteries, those vessels which carry blood from the heart to the distant tissues. In one place arterial blood is found in the veins, — the pulmonary veins, — which carry the blood from the lungs to the left side of the heart.

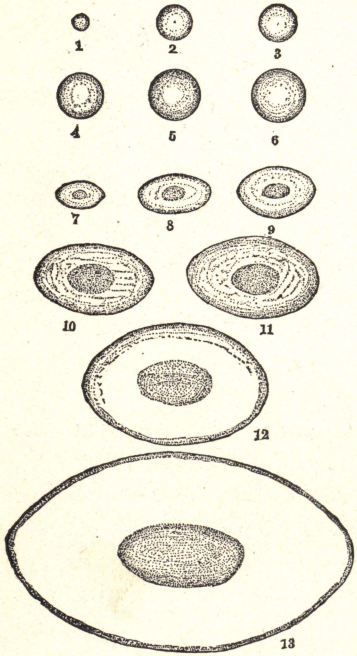


FIG. 24. — Showing the relative size of red blood corpuscles of different animals: (1) musk deer; (2) horse; (3) mouse; (4) man; (5) whale; (6) elephant; (7) humming bird; (8) pheasant; (9) pigeon; (10) snake; (11) crocodile; (12) triton; (13) proteus.

When the blood is passing through the smallest vessels, it gives up its oxygen to the tissues. Deprived of its oxygen, the hemoglobin of the red corpuscles becomes much darker in color, therefore all the blood looks darker. This darker-colored blood is called **venous** blood. It is found in the blood vessels which carry the blood from the tissues back to the heart. It is also found in one artery, — the pulmonary artery, — which carries the blood from the right side of the heart to the lungs. The arteries generally contain the bright arterial blood, and the veins the dark venous blood; but to this

rule there are the two exceptions already given, the pulmonary artery and the pulmonary veins.

Oxygen and Carbon Dioxide. — The air we breathe consists principally of two gases, — **oxygen** and **nitrogen**. The oxygen is essential to all life. Without it, we should soon die. All parts of the body need it. The tissues are constantly demanding it, and countless numbers of red blood corpuscles are continuously and rapidly at work distributing it throughout the body.

We know that a substance called carbon forms a part of all the tissues of the body. When the oxygen reaches the tissues, it unites with their carbon, forming carbon dioxide. This is a poisonous gas, and the body must cast it off as soon as possible; therefore it mingles with the plasma of the blood and is soon carried to the lungs, where it escapes from the body.

Arterial and Venous Blood Compared. — From what has been said we are able to place in a more concise form the differences between arterial and venous blood: —

Arterial blood contains the more oxygen.

Venous blood contains the more carbon dioxide.

Arterial blood is of a bright scarlet color.

Venous blood is of a darker, nearly purplish red.

Arterial blood parts with its oxygen in the capillaries.

Venous blood parts with its carbon dioxide in the lungs.

Arterial blood contains substances for the nutrition of the tissues.

Venous blood contains the worn-out materials from the tissues.

Coagulation. — Soon after blood has escaped from a blood vessel, it thickens to a jelly-like mass. This is called the **coagulation**, or clotting of blood. Blood never

clots while in the blood vessels of the living body, unless some disease or some unusual condition be present. It is one of the wise provisions of nature, however, that coagulation takes place whenever a blood vessel is cut or wounded, thus preventing possible bleeding to death. The lower animals may be severely bruised and wounded, or may even lose a portion of a limb, laying bare large blood vessels, without fatal results. This is because the blood soon clots, forming a solid mass at the openings of the vessels and preventing any further escape of blood.

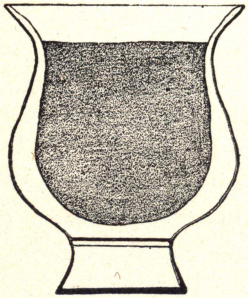


FIG. 25. — A bowl of recently coagulated blood; the clot is of uniform density.

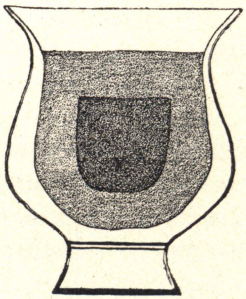


FIG. 26. — The same bowl of blood a few hours later; the clot is contracted and floats in the liquid serum.

Whenever any vessel of considerable size in the human body is ruptured, it is advisable to aid nature by checking the flow of blood for a short time, in order that the clot may be well formed. This is accomplished by pressing on the part, which any one of us could do, or by placing a fine thread around the ends of the ruptured vessel; this must be done by a surgeon.

The clotting of the blood is due to the change of some of its liquid elements into a substance called **fibrin**. Fibrin consists of innumerable delicate fibrils, so minute that they

are seen only with the higher powers of the microscope. The fibrils are like so many minute threads, which entangle the blood corpuscles and form with them a soft, semifluid mass. In a few moments after blood has been exposed to the air, it begins to change, as has been stated, to a jelly-like mass. Later the mass begins to contract, while there escapes from it a clear fluid, called the **serum.** Still later the central mass becomes quite hard, so that it may be cut with a knife. This central hard mass is known as the **clot**, and consists of the fibrin and the corpuscles ; while the serum represents the other constituents of the blood. (See Figs. 25 and 26.)

The Spleen. — The spleen is a small organ of less than one half pound in weight. It is situated to the left of the stomach, and is directly concerned in the formation of the blood corpuscles, both the white and the red.

The Effects of Alcohol on Blood Corpuscles. — G. W. Sims Woodhead, professor of pathology in Cambridge University, England, gives the following testimony: —

"When I was Superintendent of the Laboratory of the Royal College of Physicians in Edinburgh, I had the opportunity of observing a number of experiments carried out by Dr. D. W. Aitken . . . in which he showed that alcohol has a special affinity for the coloring matter of the red blood corpuscles, which appear not only to take up less oxygen but also to part less readily with that which they do absorb. The red blood corpuscles in fact are hampered in two functions. They absorb less, and that which they do absorb is less available, so they cannot carry on their useful work properly, and the normal tissue changes usually carried out in the body are interfered with."

CHAPTER X

THE CIRCULATION

We have learned that new material, absorbed from the digested food, must be carried to all parts of the body, for its proper nourishment; and we have also learned that old or useless material must be removed from the body. This process of repair and waste is constantly going on; and the blood is the great circulating medium through which these changes take place.

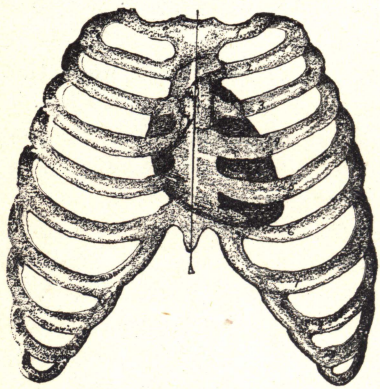


Fig. 27. — The position of the heart.

There are four different parts to be studied in connection with the circulation of the blood, — the heart, the arteries, the capillaries, and the veins.

The Heart. — The heart is a large hollow muscle placed obliquely in the chest cavity between the lungs. It weighs from ten to twelve ounces and measures about five inches in length. It is conical in shape, with the apex of the cone pointing downward, forward, and to the left. The location of the apex can be easily determined by placing the hand over the left side, and feeling the strokes against the walls of the chest.

PLATE II.—Showing the general plan of the circulation: The arrows indicate the direction in which the blood flows. The purification of the blood in the lungs (1, 2) is suggested by the difference in coloring between the dark-red, impure blood, as it enters the lungs from the right side of the heart (3) and the bright red, purified blood which is carried from the lungs to the left side of the heart (4); The purified arterial blood then passes into the aorta, some of it leaving through the branches (5, 8), to supply the upper extremities; and through the branches (6, 7) to supply the head. The purified blood also passes down the abdominal aorta (13) to supply the trunk and lower extremities.

The impure venous blood returns to the right side of the heart, from the upper extremities, through the veins (9, 12) and from the head through (10, 11). From the trunk and lower extremities it returns through the large vein (14).

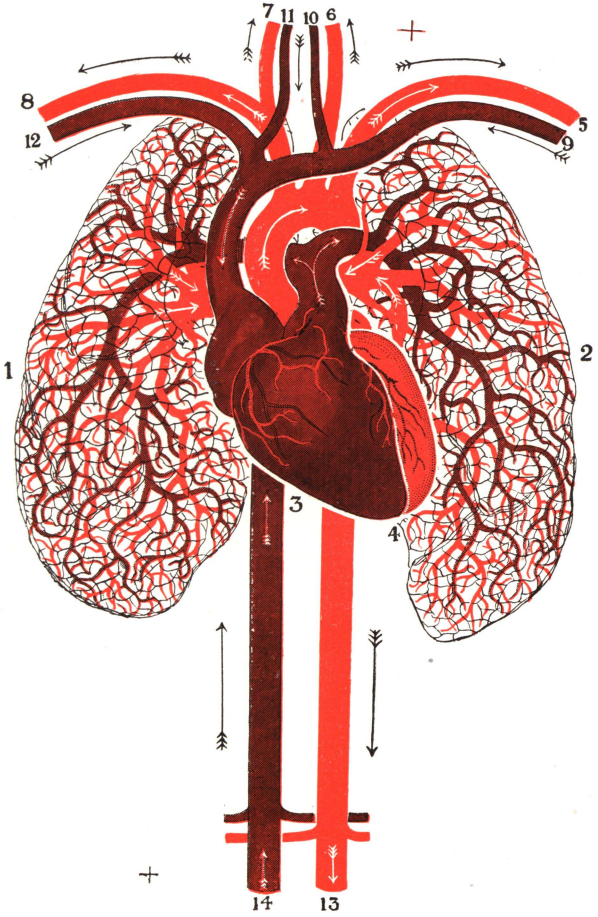


PLATE II.

The apex has considerable freedom of motion, while the base, or upper end of the heart, has but little motion.

A reference to Fig. 27 shows that the heart is not all on the left side of the body. It extends about three inches to the left of the median line, and an inch and a half to the right of it.

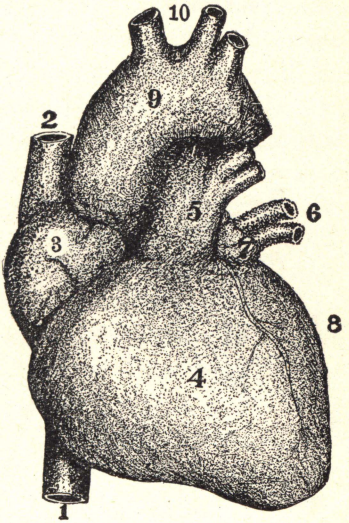


FIG. 28. — The heart and the larger vessels at its base or upper part: (1) and (2) veins; (3) right auricle; (4) right ventricle; (5) pulmonary artery; (6) pulmonary veins; (7) left auricle; (8) left ventricle; (9) aorta; (10) branches from the aorta.

The Pericardium. — The heart is completely surrounded by a sac or membranous bag, called the **pericardium**, the lower part of which rests on the diaphragm. The cells which cover the inside of the pericardium secrete a watery fluid which keeps its inner lining very smooth and enables the heart to move against it without friction.

Cavities of the Heart. — The heart is divided lengthwise by a firm muscular wall. There is no opening in this wall, hence there is no connection between the two sides of the heart. One side, the left, always contains arterial blood; and the other side, the right, venous blood.

Each side of the heart is also divided into two parts by a wall, which, in this case, is placed crosswise. But this cross wall is not complete; there is an opening in it, so that the blood freely passes from the upper part to the lower part. This opening is protected by valves which

do not allow the blood to pass in the other direction. Thus there are four cavities in the heart.

The two upper cavities are called **auricles**, from their fancied resemblance to ears; the two lower cavities are called **ventricles**. Each side of the heart consists of an auricle above and a ventricle below. All these cavities are lined with a very smooth membrane.

A careful study of Fig. 28 will lead to a better understanding of these divisions of the heart. The right side of the heart is represented at (3) and (4), while (7) and (8) represent the left side. The firm muscular wall which divides the heart lengthwise is directly beneath the small blood vessel shown on the outside of the heart, to the left of the number (8). The right side of the heart is here represented as composed of an auricle at (3) and a ventricle at (4). The left side of the heart is nearly hidden from view, but a part of its auricle (7) and of its ventricle (8) can be seen. At (1) and (2) are represented the veins which carry the blood from the distant parts of the body to the right side of the heart. The largest artery in the body, which is called the **aorta**, is shown at (9).

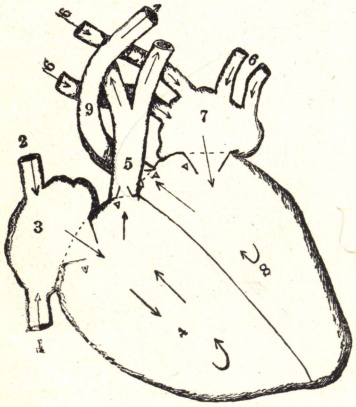


FIG. 29. — A diagram illustrating the flow of blood through the heart: (1) and (2) veins; (3) right auricle; (4) right ventricle; (5) pulmonary artery; (6) pulmonary veins; (7) left auricle; (8) left ventricle; (9) aorta.

The Contractions of the Heart. — Since the heart is a muscle, it has the power of contracting. When the

auricles contract, the blood is forced into the ventricles. As soon as this occurs the ventricles contract, forcing the blood out into the arteries. The flow of the blood is always onward, because there are valves that prevent its setting back into the heart. Such valves are found between the auricles and the ventricles, and also between the ventricles and the arteries.

The Course of the Blood. — In tracing the course of the blood through the body, we might start anywhere in the circulatory system because, as the heart is always pumping, and the blood is always flowing, there is no beginning point. But, to follow the round, let us imagine that the left ventricle of the heart, Fig. 29 (8), has contracted, forcing the blood into the large artery (9). The blood then travels through this artery into the many branches which lead out from it; these branch arteries grow smaller and smaller until finally they join the still finer blood vessels called **capillaries**. The capillaries are very small tubes which go to every part of the body. In them the blood flows more slowly and is brought into contact with the individual cells. It is here that the blood gives to the tissues the nourishment that it carries, and here the materials that the tissues have worn out in doing their work are given off to the blood. From the capillaries the blood, now carrying the impurities it has taken up, passes into somewhat larger vessels which the capillaries unite to form. These are the **veins**, and they increase in size as one joins another, making larger and larger veins — finally all the veins unite into two large veins, Fig. 29 (1) (2), which carry the now impure blood back to the heart again and pour it into the right auricle. After this auricle becomes filled, it contracts and forces the blood in the direction of the arrowheads into the

right ventricle (4). When the ventricle is filled, it contracts and forces the blood in the direction of the arrowheads into the pulmonary artery, through which it is carried to the lungs.

This dark blood then flows through the lungs, giving off its carbonic acid gas there and receiving a fresh supply of oxygen. This is illustrated in Plate II. After passing through the lungs, it enters the pulmonary veins (6) as bright, purified, arterial blood. These veins carry the blood to the left auricle (7), which contracts, as did the right auricle, forcing the blood into the left ventricle. From there it starts on another course through the body, such as we have just traced.

This description of the blood's travels is necessarily incomplete, and will need some correction if taken too literally. While the general course of the blood is the same, we must not get the notion that it all travels the same path, or that it all makes the entire circuit of the body. For instance, the blood that goes at any one moment from the heart to the arteries in the shoulder naturally makes its trip quicker and returns again through the veins to the heart earlier than the blood does that starts at the same time through the blood vessels that go to the feet.

The Left Ventricle Stronger than the Right. — The left ventricle has to contract with force sufficient to send the blood to the most distant parts of the body; while the right ventricle has to send the blood only to the lungs, which are but a short distance from it. Therefore, we find that the muscular walls of the left side of the heart are much thicker and stronger than those of the right side.

The Beating of the Heart. — The throbbing movement of the heart is called the **beat** of the heart. It is subject

to much variation and is involuntary. In man, the heart beats about 70 times per minute ; in woman, about 80 times per minute. This average may be greatly increased for a short time by many circumstances, as by violent exercise or excitement; but if the increase be long continued, it denotes some disturbance of the system. If the heart beats continuously 150 or 160 times a minute, the condition indicates great danger. Serious trouble is also generally indicated when the heart beats less than the normal number of times. The heart beat varies greatly with the age. At birth it is about 130. It gradually falls until at three years of age it is about 100; at fourteen, about 80; and at twenty-one, about the average for the adult.

Exercise of all kinds accelerates the beating of the heart. Even the muscular effort of standing increases its rapidity. The heart beats are about ten more per minute when one is standing than when one is lying down. When one runs and jumps, the heart beats faster. Hence if, in taking violent exercise, the heart begins to beat too rapidly, one can usually relieve it by lying down. Any sudden excitement, as fright, will cause the heart to beat violently, so that it is felt to strike with much force against the walls of the chest. Excessive fear, joy, or grief may also have an effect on the nervous system powerful enough to cause the heart's action to cease, producing instant death. Sorrow and depression of spirits may cause the number of beats to be reduced. Taking the seasons through, we are told that the heart beats faster in summer than in winter.

The Heart Works and Rests. — The heart does an immense amount of work. At the rate of seventy beats per minute, there are a hundred thousand contractions daily. The labor expended by the heart each day is

equal to the force required to lift one hundred and twenty tons a foot from the ground.

If the heart does such an amount of work, it must have rest. We find there is a period of time when it is completely at rest. The auricles contract together ; immediately after, the ventricles contract, also ; and following their contraction there is a period of complete rest, after which the auricles contract again. Brief as this period is, it yet represents about one fourth of the time of a whole beat. From this it is seen that the sum of all these brief periods of rest is in a whole day not less than six hours.

The Sounds of the Heart. — If we listen to the heart beats, by placing an ear over the heart, two distinct sounds are heard, one immediately following the other. After an instant of silence they are repeated. It is noticed that these two sounds correspond with each beat of the heart. The first sound is comparatively long and dull ; the second, almost immediately following it, is sharper, shorter, and more distinct. The sounds are likened to those produced by pronouncing the words *tŭbb*, *dŭp*.

The first sound is caused (1) by the sudden closure of the valves which are between the auricles and the ventricles, together with (2) the sound caused by the powerful contraction of the muscular walls of the ventricles. The first sound is, therefore, a valve sound and a muscle sound. The second sound is caused by the sudden closure of the valves which are at the beginning of the pulmonary artery and the aorta. It is, therefore, entirely a valve sound.

The Pulse. — The **pulse** is a throbbing pressure corresponding to the beat of the heart. It may be felt at the

radial artery near the wrist, at the **temporal** artery over the temples, and in other places. The pulse is caused by the contraction of the ventricles, and the consequent expansion of the arteries. For instance, each contraction of the heart suddenly forces a quantity of blood into the arteries. The walls of the arteries expand to accommodate the extra amount of blood thus forced into them, and this expansion is felt near the wrist as the pulse. When the heart relaxes, the arteries would force the blood back into it, were it not for the closure of the valves, which fully prevent any backward flow. As the blood cannot go in a backward direction, it is pushed forward under the pressure of the elastic walls of the arteries. Thus the arteries relieve themselves of the excess of blood, so that their walls do not remain so fully distended. But no sooner have the arteries returned to their former size than they are again expanded by another contraction of the heart. This constant series of expansions of the

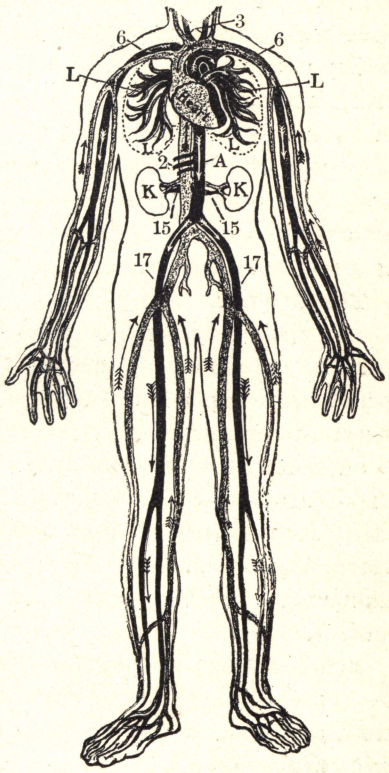


FIG. 30. — The general plan of the circulation. (See pp. 86 and 87.)

arteries gives rise to the pulse, which is present in all arteries. Therefore each arterial expansion, or each pulse, represents a contraction of the ventricles. The pulse thus becomes a guide for ascertaining the frequency and regularity of the heart's action, and the condition of the general circulation.

As nearly all the arteries are deep-seated, only those few near the surface, as mentioned above, are used to study the pulse. It is possible to see the pulsations of an artery with the unaided eye, such pulsations showing at times on the temple, on the neck, or at the wrist.

The Arteries. — The arteries, as we have seen, are the vessels which carry the blood from the heart to the various parts of the body. They are firm tubes, the walls of which are composed of elastic and muscular tissue. The muscle is of the involuntary variety, and the walls are so arranged in the tube as to give the artery the power of expanding and of contracting so that it can accommodate itself to the amount of blood it contains. The largest artery in the body is the **aorta**, which is nearly an inch in diameter. It is the great central artery of the body. If an artery is cut across it will retain its circular form because of its elastic and muscular walls. After repeated divisions of the arteries, they become very small, so that they can only be seen with the highest powers of the microscope.

Names of Principal Arteries. — In Fig. 30 we have a diagram of the general plan of circulation. The darker lines represent the arteries, which carry blood away from the heart, the lighter lines represent the veins, which carry blood toward the heart. The numbering here given corresponds with that on Plate III. (3) Carotid arteries, one for each side of the neck. The beat of these arteries may generally be felt by placing the fingers on the side of the neck. These arteries carry the blood to the head. (6) Large arteries beneath the clavicle.

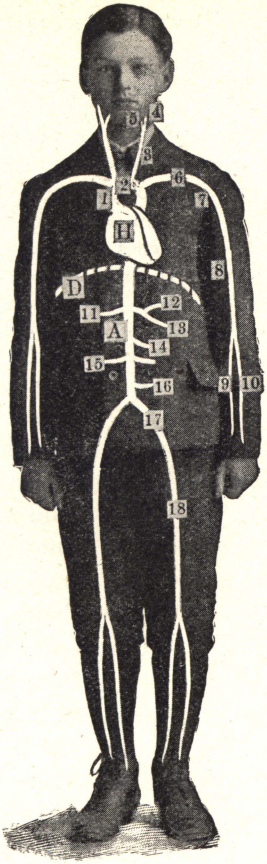


PLATE III

The general plan of circulation, and the names of the principal arteries: *D*, diaphragm; *H*, heart; *A*, abdominal aorta; (1) the aorta; (2) arch of the aorta; (3) the carotid; (4) the external carotid, supplying blood to the outer surface of the head; (5) the internal carotid, to brain and eyes; (6) the subclavian, situated beneath the clavicle; (7) the axillary, in the axilla or armpit; (8) the brachial, lying along the inner side of the arm; (9) the radial, on the radial side of the forearm; (10) the ulnar, on the ulnar side of the forearm; (11) the hepatic, to the liver; (12) the gastric, to the stomach; (13) the splenic, to the spleen; (14) the superior mesenteric, to the small intestines and a portion of the large intestine; (15) the renal, to the kidneys; (16) the inferior mesenteric, to a portion of the large intestine; (17) the common iliac, a division of the aorta; (18) the femoral.

As each of them extends down the under side of the arm it is called the brachial artery. At the elbow it divides into two arteries, one by the side of the radius being called the radial artery, and the other at the side of the ulna being called the ulnar artery. (L) Arteries of the lungs. (A) Continuation of the aorta. When the aorta reaches the abdomen, as here illustrated, it is called the abdominal aorta. At this point are seen three branches from the abdominal aorta; one supplying the liver, another the spleen, and another the stomach. (17) When the abdominal aorta reaches the lower part of the abdomen it divides into two large arteries, one for each leg. When each of the divisions reaches the thigh it is called the femoral artery, because it is by the side of the femur. (15) Arteries which supply the kidneys (K).

The Capillaries. — When an artery has become so small that even the muscular and elastic coats have disappeared, and only the thin lining membrane is left, it is called a **capillary**. We have traced the blood current through the arteries into these most minute blood vessels, the capillaries, which penetrate the organs and tissues of the body. We have found that here the blood is brought into very close contact with the cells of the tissues; for between the living tissues and the blood in a capillary, there are but two of the thinnest membranes. Many of the capillaries are so small that when the blood flows through them, the corpuscles, tiny as they are, have to pass in single file, as there is not room enough for them side by side (Fig. 31).

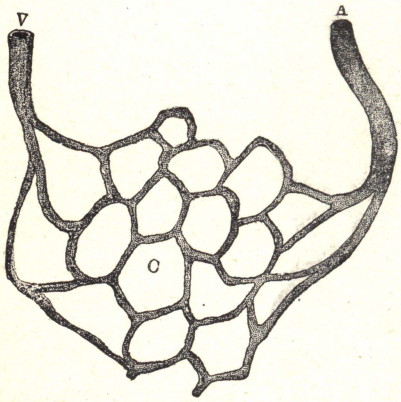


FIG. 31. — A, a small artery; C, capillaries; V, a small vein, magnified.

The Veins. — The capillaries in turn unite with each other to make larger vessels, which are called **veins.** The veins convey the blood from the capillaries to the heart. The smaller veins unite to make larger ones, until at last the large veins are formed which empty into the right auricle of the heart. The walls of the veins are much thinner and less elastic than the walls of the arteries.

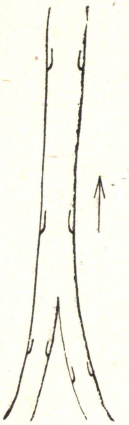


FIG. 32. — The valves of a vein, open.

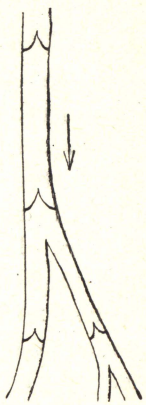


FIG. 33. — The valves of a vein, closed.

Nearly all the veins have valves to prevent the backward flow of the blood. This is illustrated in Figs. 32 and 33. It is evident that if the blood flows in the direction of the arrowhead, in Fig. 32, the valves will remain open, but if it should attempt to flow in the opposite direction, as in Fig. 33, the valves would close and completely shut off the passage.

Generally speaking, the veins are placed side by side with the arteries, and have corresponding names. The large vein by the side of the aorta is called the **inferior vena cava.**

Rapidity of the Circulation. — The blood nearest the heart, in the aorta, flows the most rapidly, because all the force of the heart's contraction makes itself felt here. As the arteries divide, the stream becomes less rapid until in the capillaries it is much slower. It is estimated that the blood near the heart flows five hundred times faster than

it does in the capillaries. In the large arteries near the heart, the blood flows at the rate of about a foot per second. In the veins the flow is not so rapid as in the arteries, but is more rapid than in the capillaries. A quantity of blood can leave the heart, make a complete round of the body, and reach its starting place again in less than half a minute.

It is impossible to show in any diagram the marvelous intricacy of the circulation of the blood; through which, as we have learned, all the different parts of the body are fed, and are also, as we shall soon learn, purified. Still Plate IV may be very helpful to us in the effort to picture these wonderful operations. It is intended to suggest the connections and relations of the different parts of the system, but is by no means an exact illustration of the process as it takes place in any one part.

Aids to the Circulation. — The heart itself is capable of contracting with sufficient force to send the blood on its complete round of the circulation. But there are many aids to this force. Exercise is one of the most important. It not only causes the heart to beat faster and thus hastens the flow of blood, but it is a direct aid to the movement of blood in the veins. When a vein is filled, the blood cannot flow backward toward the capillaries on account of the valves; therefore, if the muscles be made to contract and thereby press upon the veins, the blood will be pushed onward faster. When the muscles relax, the vein is again filled with blood coming from the capillaries. More muscular exercise will again hasten on the blood to the heart.

Very tight clothing is a hindrance to the circulation.

Effects of Alcoholic Drinks on the Circulation. — The habitual use of alcoholic drinks is often a cause of heart

PLATE IV.—A diagram of the circulatory system intended to show the manner in which the blood travels through the body. In the lungs (1), the blood is purified as shown in the change from dark red to light red, the blood leaves the lungs through the pulmonary veins (2), through which it enters the left auricle of the heart (3); the purified blood then passes into (4), the left ventricle; then out into the arteries represented by (5); then into the capillaries represented by (6); then into the veins (7); and back to the right auricle of the heart (8); to the right ventricle (9); through the pulmonary artery (10); to the lungs again, for purification.

Note that the short circuit from the heart to the upper part of the body is illustrated by (5) (6) (7), at the top of the figure, and the longer circuit by (5) (6) (7) at the bottom of the figure.

There are also represented the capillaries of the liver (11), the spleen (12), the alimentary canal (13), and the kidneys (14).

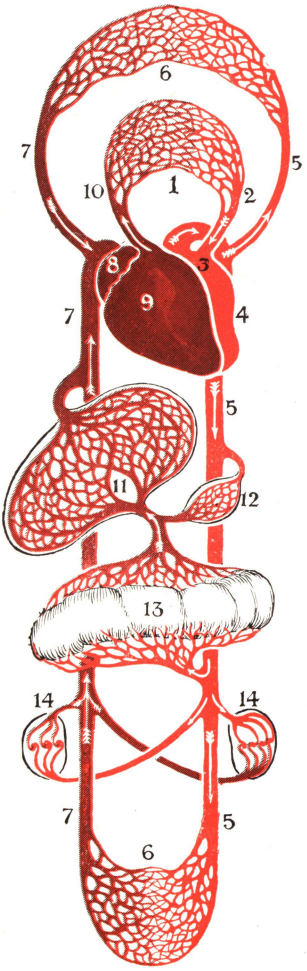


PLATE IV.

disease. The muscles of the heart become thickened and the cavities enlarged. A process of degeneration begins. Particles of fat, or oil, take the place of the muscle. At first, this is very slight; but gradually much of the worn-out muscle disappears and fatty tissue takes its place. Physicians call this trouble "fatty degeneration of the heart." The heart becomes weaker and weaker, until, suddenly, it is unable to do its work longer, and death occurs.

It is not necessary that the strongest drinks be used to produce these changes. The extra amount of flesh found in those who use ale and beer freely is of this fatty nature; and a fatty heart is what we should expect to find in such a fleshy body.

Changes of like nature may also take place in the muscular tissue of the walls of the arteries. The cells become weakened by the deposit of fat within them, and the walls of the arteries lose some of their strength. This makes the walls more liable to rupture, and is one of the predisposing causes of apoplexy.

Alcohol and the Smaller Vessels. — The walls of the smaller arteries consist largely of muscular tissue. This tissue is kept continuously in a partially contracted condition, in order that the walls may be more firm. The muscular tissue is under the control of minute nerves. These nerves are capable of making the muscle contract firmly, thereby diminishing the size of the vessel; while if they cease to act, from any cause, the muscle relaxes and the size of the vessel is greatly increased.

The small arteries are said to have "tone" when these nerves exert their power, and keep the muscle in its usual condition of moderate contraction. The walls of the smaller arteries, therefore, are normally in a state of moderate contraction. The effect of alcohol is partially to

paralyze the center that controls the muscular tissue, so that it ceases to exert its full power. If a small dose of an alcoholic beverage be taken, the effect may be slight and only temporary, as illustrated in the flushing of the face; if not repeated, recovery may be complete; but a continuation of such doses causes the paralysis to become more permanent, and the nervous system to lose its power of controlling the size of the blood vessels.

Not only the red nose and the red eyes of the confirmed drinker, but the reddened face and distended capillaries often seen in the moderate drinker, are indications of the paralysis of these little nerves. The "tone" has disappeared from the walls of the blood vessels; the muscular tissue is becoming or has become permanently relaxed, and the vessels are constantly in a distended condition. But the nose, eyes, and other portions of the face are not the only places where this congestion occurs. It exists in the mucous membranes of the body to a large extent; while many of the organs and tissues are also in this chronic congested condition.

Professor G. Sims Woodhead of Cambridge University, says: "Alcohol is said to have a stimulating effect on the heart muscle. If its effect on the heart muscle is in any way similar to that exerted by it on the voluntary muscles, the effect is merely temporary, and is followed by a period of depression, during which the muscle does so much less work that there is a considerable falling off in the amount of work done, the greater the preliminary stimulation the greater the amount of falling off in later periods."

Dr. Edward L. Fox, in an annual address, as president of the British Medical Association, said, "It [alcohol] not only fails in giving power in the work of the muscles of the heart, but acts distinctly as a depressant."

Tobacco and the Heart. — Tobacco affects the heart largely through the action of the nicotine on the nervous

system. A prolonged use of tobacco frequently gives rise to a particular affection known as the "tobacco heart." The author has seen a strikingly large number of these cases in young men between fifteen and twenty years of age. The heart is irregular in its action and sometimes beats with great force. This is often accompanied with a sensation of weakness or of great anxiety. There are occasional attacks of dizziness, shortness of breath, nausea, and vomiting. At times there is intense pain in the region of the heart. Tobacco will not make as serious changes in the structure of the heart as those caused by alcohol, yet it is capable of doing immense harm.

Dr. A. Clinton of San Francisco, physician to several boys' schools, says: "A good deal has been said about the evils of cigarette smoking, but not one half the truth has ever been told. Cigarette smoking first blunts the whole moral nature. It has an appalling effect upon the physical system as well. It first stimulates and then stupefies the nerves. It sends boys into consumption. It gives them enlargement of the heart, and it sends them to the insane asylum. I am often called in to prescribe for boys for palpitation of the heart. In nine cases out of ten this is caused by the cigarette habit. I have seen bright boys turned into dunces, and straightforward, honest boys made into miserable cowards by cigarette smoking. I am speaking the truth, nearly every physician and nearly every teacher knows."

Dr. H. A. Caley, writing in the *Lancet*, June, 1899, said: "In strict training just those agents and influences are eliminated which either directly or indirectly depress the heart and interfere with its muscular vigor — as, for example, alcohol and tobacco. They are avoided when the heart is to be driven at high pressure."

There have been instances among our most prominent statesmen, where death was instantaneous, as a result of disease of the heart from the long-continued use of tobacco. With such a history tobacco should no longer be regarded as a luxury, but rather as a slow poison capable of accomplishing an enormous amount of damage.

CHAPTER XI

RESPIRATION

Respiration. — The function by which oxygen is introduced into the body, and carbon dioxide is removed from it, is called **respiration.**

Ordinary respiration is involuntary. We breathe when we are not thinking of it, and breathe as regularly when asleep as when awake. But respiration is also partly voluntary, for it is possible to breathe for a short time more slowly or more rapidly than usual. By taking advantage of this fact, the respiratory muscles can be greatly strengthened.

A Lung Exercise. — Raise the arms slowly from the sides, at the same time drawing a long, deep breath. Then let the arms gradually fall while you blow the air out slowly through the mouth. This exercise will change the air in the lower part of the lungs, strengthen the lungs themselves, and increase their capacity. All this aids greatly in maintaining the general health and that of the lungs.

Crying and laughing are voluntary respiratory movements, principally spasmodic contractions of the diaphragm. Even these movements may become involuntary; the spasmodic action of the diaphragm may go beyond the individual's control, so that for a time it is impossible to cease laughing or crying.

Number of Respirations. — The number of respirations should be about one to every four beats of the pulse. As

the average pulse of the male adult is about seventy, so the number of respirations should be about eighteen. But this is influenced by many conditions; as, the size of the lungs, the condition of the air, by exercise, singing, speaking, and other circumstances. The number cannot, however, be lowered for any considerable length of time; the demands of the system for more oxygen and for an escape of the carbon dioxide are so great that it is impossible to resist them.

The Nasal Cavities. — The **nostrils** are the proper channels through which the air should reach the lungs. The nose has at least three important functions to perform in connection with respiration: these are to warm, to moisten, and to filter the inspired air.

The first of these is evidently very important; for if the cold air of winter should be brought directly in contact with the tissues of the throat, inflammation would be likely to follow, causing sore throat, hoarseness, and loss of voice. The tissues of the nasal cavities are so well supplied with blood that they are capable of warming the air as it passes over them, until its temperature more nearly equals that of the body.

The second function is likewise important: there is at least a pint of liquid secreted every twenty-four hours by the mucous membrane lining the nose; the air we inhale passes through the nose, takes up this moisture, and becomes saturated with it. That the air takes moisture from the tissues is easily proven by breathing through the mouth for a short time. As we breathe in this way, we find that the throat soon becomes dry, and swallowing is difficult.

The third function is much like that of a filter. The cells covering much of the lining membrane of the nose

are supplied with little hairlike processes. These fine processes, or "cilia," catch the particles of matter found in dust and smoke, and in the ordinary air breathed in. In this way the nose acts as a filter.

Mouth Breathing. — When breathed through the mouth, the air is but little warmed, is only slightly moistened, and is not filtered. Mouth breathing brings the air into contact with the larynx, trachea, and bronchial tubes, scarcely changed. It is still cold, dry, irritating, and, as a result, produces more or less inflammation. Inflammation of the throat, enlarged tonsils, chronic hoarseness, and coughs are some of the affections which result from the pernicious habit of breathing through the mouth. Nature intended that we should breathe through the nose, and a number of evils will result if we fail in so doing. If it be impossible to get air through the nose, a physician should be consulted, that the difficulty may be removed. Early attention to these conditions would do much to prevent the catarrhal affections so prevalent in this country.

Presence of Adenoids. — If a child is forced to breathe with the mouth open, then something is wrong, and a physician should be consulted in order that the trouble may be promptly remedied. Often the obstruction in the nose is due to the presence of growths called adenoids. These growths are in the back part of the passages of the nose; they greatly interfere with speech, are often the cause of deafness, and if allowed to remain may be the cause of an unpleasant change in the countenance. They are injurious to health and should always be promptly removed as soon as their presence is determined.

The Larynx. — After the air breathed in has passed through the nose, it passes down the throat, until about opposite the base of the tongue. Here it enters the upper

part of the **larynx**, which is the organ of voice. This is situated at the upper and front part of the neck, and can be felt as a hard lump, more prominent in men than in women, commonly known as "Adam's apple." The larynx is about an inch and a half long and an inch in diameter. It is composed of cartilages, lined with mucous membrane. In about the middle of its interior are two strong bands of elastic tissue, called the **vocal cords**, by means of which we are able to make sounds. These cords extend from the front to the back of the cavity of the larynx. The space

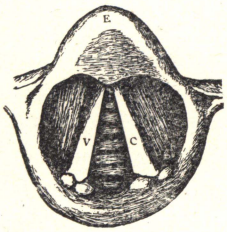


FIG. 34. — The position of the vocal cords during inspiration: the rings of the trachea are seen between the vocal cords. VC, vocal cords; E, epiglottis.

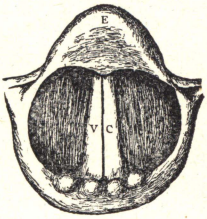


FIG. 35. — The position of the vocal cords when uttering a high note: VC, vocal cords; E, epiglottis.

between them, through which the air passes, is called the **glottis**: this opening varies in size according to the tension of the vocal cords. This is well illustrated by referring to Figs. 34 and 35. When we breathe, the vocal cords are quiet, and the opening between them is large, as in Fig. 34; but when sounds are produced, the vocal cords come together and the glottis is narrowed. The "pitch" of the voice depends upon the length of the vocal cords; the longer cords producing the lower tones. For this reason, the voice is shrill in children, and usually higher in women than in men. The boy's larynx grows rapidly

at twelve or fourteen years of age, causing the voice to "break" easily, and gradually to change to a lower pitch.

The Epiglottis. — The entrance to the larynx is protected by a valve called the **epiglottis.** During respiration, the epiglottis is directed upward, so that the larynx is open; but during the act of swallowing, the epiglottis shuts tightly down over the larynx, preventing the entrance of any solid or liquid. Occasionally, however, a particle of food, on its way to the œsophagus, "goes the wrong way" and slips into the larynx, when a violent cough is necessary for its removal. Study Fig. 36.

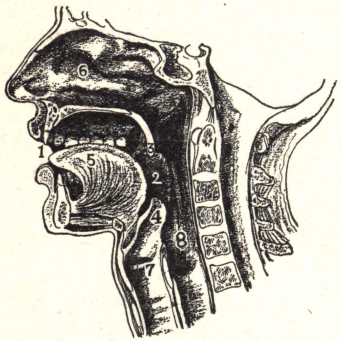


FIG. 36. — The upper air passages, and their relation to surrounding structures: (1) the mouth; (2) the pharynx; (3) the uvula; (4) the epiglottis; (5) the tongue; (6) the nasal passages; (7) the larynx; (8) the œsophagus.

The Trachea. — The **trachea**, commonly known as the **windpipe,** is continuous with the lower part of the larynx; it consists of a number of rings of cartilage. The rings are placed one over the other, separated only by a narrow membrane. They keep the trachea from collapsing, thus always insuring a free passage for the air. The tube is lined its whole length with a mucous membrane. Just after entering the chest, the trachea divides into two branches, called the **bronchi,** one branch going to each lung.

The Bronchi and the Air Cells. — After entering the lungs, the bronchi divide again and again, until they are very minute in size. They are everywhere lined with a mucous membrane. A study of Fig. 37 will make these facts more clear. Note the bronchial tubes, shown in

the right lung (4). There are also similar tubes in the left lung (5), but they are not visible in the figure. After these tubes have become very small, from their repeated divisions, they terminate in a collection of minute sacs, called **air cells**. The walls of these air cells are very thin and highly elastic. Fig. 38 shows a terminal bronchial tube with its air cells. If we bear in mind that these air cells have elastic walls, it is easy to imagine how they could be inflated, like so many rubber sacs, by forcing air into the tube, at (1). This is practically about what occurs when we draw in an ordinary breath.

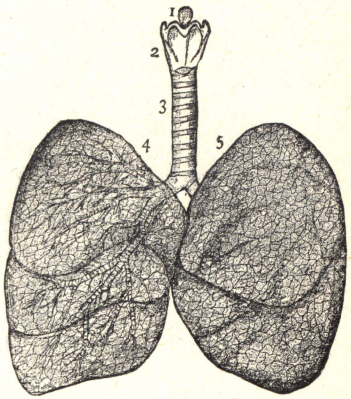


FIG. 37. — (1) The epiglottis; (2) the larynx; (3) the trachea; (4) the right lung; (5) the left lung.

The inner surface of these air cells is exposed to the air which enters the lungs. The amount of surface thus exposed is very great, being estimated to be at least fourteen hundred square feet. Surrounding the outer walls of the air cells is a dense network of capillary blood vessels. Thus the blood itself is separated from the air only by the thin wall of the blood vessel and the fine membrane of the air cell. It is here, in the air cells, that the changes occur which transform the dark venous blood into the bright arterial blood.

The Lungs. — The two lungs are situated in the thoracic cavity, one in each side of the chest. Owing to the amount of elastic tissue in the air cells, the lungs have great power of expansion. When removed from the

body, they appear completely collapsed; still they float in water on account of the air yet remaining in the air cells. When in this collapsed condition, if a tube be placed in the trachea, the lungs may be inflated by blowing or by forcing air into the tube. After the inflation, it is only necessary to remove the tube, or allow the air to escape through it, when the lungs will immediately collapse again. Thus it is easily proved that if some force be applied to send air into the lungs, the elastic tissue in the air cells will stretch like rubber; and that as soon as the force is removed, the elastic tissue will return to its former condition.

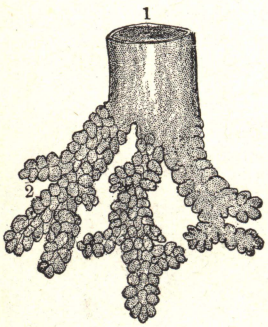


FIG. 38. — (1) The end of a small bronchial tube; (2) air cells.

The Pleura. — The **pleura** is a double membrane, covering the inside of the thoracic cavity and the lungs. One membrane is closely fastened to the inner walls of the chest, while the other covers the surface of the lungs. The space between these membranes is called the **pleural cavity.** The pleura secretes a fluid, so that its two surfaces may move against each other easily and without friction, as they do in ordinary breathing. An inflammation of this membrane is called pleurisy; it is extremely painful, because each time a breath is taken, the lungs expand, causing the inflamed membrane covering the lungs to move against another inflamed membrane which forms the lining of the walls of the chest.

Why Air enters the Lungs. — The mechanism of respiration is not unlike that of a pair of bellows. When the

handles are raised, the inside of the bellows is made larger, and the air rushes in to fill the extra space.

The chest is a tight box, with only one opening, and that at the top, — the larynx. If this box be suddenly enlarged, the air will rush in through the opening; this is called **inspiration.** When the box ceases to enlarge, no more air enters. Immediately all the parts tend to return to their former condition, the box is made smaller, and the air rushes out of the opening at the top; this is called **expiration.** From this we conclude that air enters the lungs because the chest is made larger; and that it leaves the lungs because of the elastic nature of the lung substance. Before considering how the chest box is enlarged, it will be well to fix in the mind the shape of the thoracic cavity, its contents, and the relation of certain organs to each other. A reference to Fig. 39 will show these relations. The lungs rise slightly above the collar bone (2) to form the apex of the chest: below, they rest upon the curved diaphragm (6), which divides the thoracic from the abdominal cavity. The relative

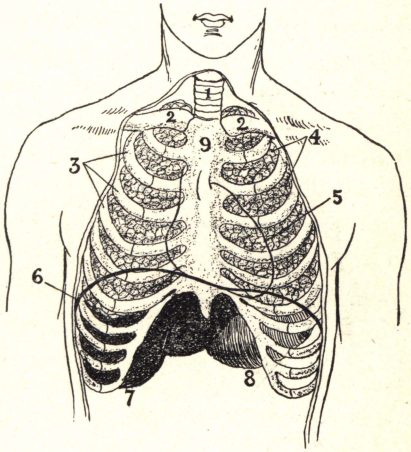


FIG. 39. — The position of the lungs, and their relation to certain organs: (1) the trachea; (2) the clavicle; (3) the ribs; (4) the lungs; (5) a dark curved line, showing the position of the heart; (6) the diaphragm, extending in a curved direction from one side to the other; (7) the liver; (8) the stomach; (9) the sternum.

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position of the heart is shown by the curved line (5). Pressing up against the under surface of the diaphragm, on the right side, is the liver (7), while on the left side is the stomach (8). By glancing at this figure, it is easily understood that if the lower ribs be brought tightly together from any cause, as by tight lacing, the stomach and liver will be forced up against the diaphragm. As a result of this, it would be extremely difficult for the diaphragm to move downward, or, as illustrated in the figure, for the line 6 to become shorter. The application of this fact will be seen later.

Inspiration. — When air is breathed in, the chest is enlarged in two ways. First, by the raising of the ribs

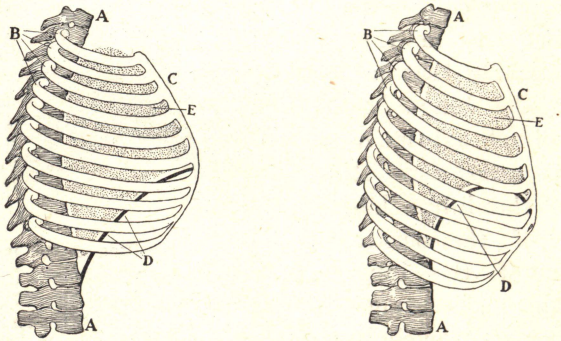


FIG. 40. — Diagrams illustrating how the thoracic cavity is enlarged, as during inspiration. A, spinal column ; B , ribs ; C, sternum ; D, diaphragm ; E, lungs. The diagram to the right illustrates the thoracic cavity during expiration ; the one to the left, during inspiration.

(which also enlarges the chest from side to side, because the ribs are curved), and second, by the contracting of the diaphragm. Attention has already been called to this thin muscle. When it relaxes, it is in the form of a vaulted partition, with its rounded portion rising into the cavity of the chest; Fig. 40, right diagram, at D. When

the diaphragm contracts, it shortens, assuming more nearly a straight line; thus the convexity becomes greatly diminished. The contraction of the diaphragm, therefore, makes it descend toward the abdomen; this must enlarge the thoracic cavity from above downward. Thus we conclude that in ordinary, quiet breathing we do not draw the air into the lungs: the air rushes in, without aid, to fill the chest, which is made larger by the elevation of the ribs and by the contraction, or lowering, of the diaphragm.

Expiration. — Ordinarily expiration, the breathing out of air, occurs without muscular effort. By the relaxation of the muscles of the chest, the ribs fall back to their natural places. The relaxation of the diaphragm aided by the pressure of the abdominal organs from beneath pushing up against it, causes it to move up again into the chest. The distended elastic tissue of the air cells now seeks to return to its natural condition, thus diminishing the size of the air cells, and consequently the size of the whole lungs; the thoracic walls keep in contact with the lungs as they diminish in size, and the air rushes out of the larynx.

Sounds of the Chest. — When the air rushes in and out of the lungs, peculiar sounds are produced. These are easily changed by unhealthy conditions of the lung tissue; the air may not enter a portion of the lungs; it may enter a cavity; or it may pass over a membrane either too dry or too moist. Any such departures from a healthy condition cause a change in the normal sounds. A careful study of these sounds enables the physician to determine the condition of the lungs.

The Inspired Air. — Each inspiration brings about twenty cubic inches, or two thirds of a pint, of air into the lungs. It is, however, carried down only a short

distance, probably not much below the larger bronchial tubes. If the air should remain there, it would be of little use, but it does not. It reaches the smallest bronchial tubes and the most tiny air cells, through what is called the "diffusion of gases," working under a very interesting law. The inspired air brings oxygen to the red corpuscles of the blood. See Plate II.

The Expired Air. — If the expired air be collected and examined, it will be found to differ from the inspired air in the following particulars: (1) It has lost oxygen. The expired air contains nearly five per cent less oxygen than the atmospheric air. (2) It has gained carbon dioxide. The expired air contains nearly a hundred times more carbon dioxide than the atmospheric air. This gas represents one of the waste products of the body, and must be removed. (3) It has absorbed water. The expired air is saturated with watery vapor. This is easily shown by breathing on a mirror, or on any polished surface. (4) It contains organic matter. The amount is usually very slight, and not easily detected. If it be in excess, it imparts a perceptible odor to the breath, which may be offensive and unheathful. Even with the ordinary amount, its presence is easily detected if a number of persons be confined in a small room where there is poor ventilation. Under such circumstances the odor becomes very offensive, remaining in the room for hours after it is vacated by the people. (5) The expired air is usually warmer. To be more exact, it is generally about the temperature of the body, being unaffected by the variable temperature of the inspired air.

Effects of Alcoholic Drinks on the Organs of Respiration. — Persons who are in the habit of using alcoholic beverages seem to be especially liable to colds and to bron-

chial affections. There is an inflamed condition of the throat and the larynx, and a slight but constant congestion of the lungs; that is, too much blood is in the lung tissue. Attacks of bronchitis are not infrequent. The chances of recovery from pneumonia are much less than with those who do not use alcoholic drinks. The liability to consumption is increased, because the weakened vitality is less able to resist the germs that cause this "great white plague," as it is sometimes called.

The following quotations embody the experience of some eminent men: —

"The drinker's incapacity to resist inflammation of the lungs is well known and dangerous." — DR. A. FRICK, Professor in the University of Zurich.

"Nothing is likely to have such a decided influence in the prevention of tuberculosis as the general adoption of the practice of total abstinence from alcohol." — DR. F. C. COLEY, in the *Lancet*.

The *Lancet* (London) of August, 1901, contains a report by Dr. F. N. Kelynack, which says: "According to F. Oliver, alcohol is particularly destructive to young people who are disposed to tuberculosis. According to Dickenson, tuberculosis is three times as frequent among drinkers as among abstinent people."

In Dr. Hector McKenzie's "Text-book of Medicine," there is the following statement, "It is almost invariable to find tubercles present in the lungs of patients dying in the course of alcoholic paralysis."

Effect of Tobacco on Respiration. — One of the most characteristic effects of tobacco is that breathing is less frequent and less deep, and the body, consequently, gets less oxygen, hence the blood is less pure and less energy is generated.

The Voice. — Four factors enter into the construction of the voice: (1) the breath, which is the power; (2) the larynx, which makes the tone; (3) the pharynx, mouth, and nose, which modify the tone; and (4) the organs of articulation.

When the breath from the lungs comes against the delicate vocal cords it causes them to vibrate, thus producing sound. The force with which the air leaves the lungs has largely to do with the loudness of the tone. The pitch of the tone, whether high or low, depends upon the thickness, length, and tension of the vocal cords. This is precisely the case with the guitar, the piano, or any other stringed instrument. The quality of the voice is determined largely by the shape of the larynx and the upper air passages.

The nervous and muscular mechanism of the larynx are indeed most marvelous. In response to the slightest nerve action, the muscles will tighten or relax the vocal cords with the most delicate nicety.

There is a very close relation existing between the senses of hearing and of speech. The vocal organs cannot be brought to their highest development unless the ear be in perfect order. In the case of the persons whom we call "deaf and dumb" there is usually no defect whatever of the vocal organs, but never having been able to hear any sounds, not even those which they unintentionally produced, such people are unable, without special teaching, to control the pitch of the voice. This is but another illustration of the necessity of caring well for the hearing.

Speech or language may be said to consist of short sounds made by the vocal cords, called vowels; and also of other sounds produced by the parts about the mouth. as the lips, tongue, palate, called consonants. The dis-

tinctness of speech depends largely upon the accuracy with which these consonants are formed. The peculiar and undesirable nasal tone which we often hear may be due to an unnatural condition of the parts, or to some trouble which might possibly be corrected by proper treatment. Sometimes the lower surface of the end of the tongue is attached too closely to the tissues beneath. Such persons cannot protrude the end of the tongue from the mouth; we say they are "tongue-tied."

We must not underrate the value of a pleasant speech and voice. In the beginning we learn to speak from imitation; hence, if a child hears harsh and coarse voices at home, he will unconsciously tend to develop the same kind of a voice. The child who hears only distinct and refined speech is receiving the best of vocal teaching. Those who have not had such advantages, or have been heedless of them, can usually by care and by attention correct the faults into which they have grown. In some cases this is quite impossible, owing to enlarged tonsils, adenoid growths, an improperly formed mouth, or other causes. But every effort should be made to discover such defects and to have them corrected, for the value to the individual of a refined and melodious voice will be more and more apparent as the years go by.

One of the best methods of cultivating a pleasing speaking voice is singing. You may not have any especial gift along this line, and may never be able to do anything more than to sing in a chorus. Yet the training which comes from such study does a great deal toward cultivating correct, distinct enunciation, and a pleasant speaking voice. Children should always be encouraged to sing. Singing is a valuable form of lung exercise; it tends to develop the chest and acts as a preventive of lung diseases.

CHAPTER XII

VENTILATION

Amount of Air Inhaled. — In the preceding chapter, it was stated that about twenty cubic inches of air are inhaled at each inspiration. Based on this statement, and making due allowances for the breathing being increased in frequency by muscular exertion, it is safe to say each person uses at least three hundred and fifty cubic feet of air, daily, in respiration.

Oxygen supports Life. — A certain amount of oxygen in the air is necessary to support all life; a much greater amount being required to support life in human beings than in some of the lower animals. In the case of man, if the amount of oxygen in the air be reduced one half, breathing continues with great difficulty.

It requires more oxygen for the burning of a candle than it does to support life for the same length of time. Advantage is often taken of this fact to test the safety of entering a well, a vault, or an underground passage. A lighted candle is lowered into the cavity; if a sufficient amount of oxygen be present, the candle will continue to burn; if not, it will be immediately extinguished. If the candle continues to burn, it will be safe for the man to enter the inclosure, for the reason that more than enough oxygen is present to support human life.

Carbon Dioxide is a Poison. — Each respiration not only takes oxygen from the air, but it also gives to it small quantities of carbon dioxide and of some other harmful

ingredients. Hence it is injurious to breathe the same air even for the second time. If the air be poor in oxygen, it will contain a large amount of carbon dioxide. As this gas is heavier than the air, it will fall when confined in a small space and left undisturbed. The air which is the least capable of supporting life is then found at the lowest level. For this reason, the air at the bottom of the well is not so pure as the air nearer the top.

An animal placed in a closed space will absorb from the air a certain amount of the oxygen, and will give off carbon dioxide. In time the inclosed atmosphere will be so saturated with carbon dioxide that no more of it will pass from the body; therefore the carbon dioxide is retained in the blood of the animal, causing speedy death. This carbon dioxide poisoning may occur while there is yet enough oxygen remaining in the air to support life.

From what has been said, we conclude that oxygen is necessary to life, and that an insufficient amount of it in the air will cause death. We conclude also that if the carbon dioxide be not removed, it may accumulate in the air, or in the body, sufficiently to cause death. The air we breathe, therefore, should have a certain amount of oxygen, and should not have an excess of carbon dioxide.

There are many ways by which a person is warned when his system needs more oxygen and has too much carbon dioxide. Headaches, restlessness, and drowsiness result from a deficiency of oxygen and a surplus of carbon dioxide. Unless the system is freely supplied with the former and can readily throw off the latter, the vital forces become lowered and the whole body predisposed to disease.

An Abundance of Air Necessary. — The above facts are given especially that we may appreciate the necessity for an abundance of fresh air. It does not follow that a person must live either out of doors or in a very large room; but it does follow that, under all circumstances, an abundant supply of fresh air should be continuously furnished to the body.

Pure Air. — The fact that the air is cold, and feels fresh to the face, is not proof that it is pure; currents of air may be loaded with poisons. Pure air contains the proper proportion of oxygen, and is free from poisonous gases and disease germs. Out-door air is not necessarily pure, as some sewer gas or decaying animal matter may be near. Yet, as a rule, out-door air is the purest.

It is not always possible to tell when the air is pure; the best ordinary test we have is the sense of smell. Upon entering a room, if the air seems "close," it is sufficient proof that better ventilation is needed. After remaining in a close room, one becomes accustomed to the odor and the closeness is not noticed, so the question of ventilation should be attended to as soon as the room is entered.

A Deficiency of Air Dangerous. — Many cases are on record where persons have been poisoned by repeatedly breathing the same air. In the holds or cabins of ships, and in the deep cells of prisons, some terrible results have occurred from this cause.

Many writers have referred to the "black hole of Calcutta" as an illustration of this fact. In a small room with only two narrow windows, there were confined one hundred and forty-six prisoners; these persons were obliged to breathe the same air over and over again, for the windows were altogether too small to allow a sufficient

amount of fresh air to enter. In eight hours one hundred and twenty-three of the prisoners were dead, while those whose lives were spared endured great suffering.

Many rooms built to accommodate large numbers at a time, have an insufficient supply of fresh air, as, for instance, schoolrooms, lecture halls, and churches. While such a deficiency may not be enough to cause death, yet the effect on the body is marked and harmful. Drowsiness, with a dull, heavy headache, often results from a stay in such a poorly ventilated room. The listless and sleepy appearance of many a scholar is simply the result of impure air, not of a dull mind. "Break open the window!" shouted a noted divine, in the midst of his discourse, as he saw many in his congregation asleep. He knew that the most brilliant speaker could not overcome the drowsy effects of impure air.

If it becomes necessary to spend a considerable time each day in a poorly ventilated or overcrowded room, the whole body suffers. Living in poorly ventilated rooms enfeebles the whole body; the appetite fails, the red corpuscles are reduced in number, the skin becomes colorless, and the entire system shows that it is suffering from too little oxygen and from too much carbon dioxide. Colds and coughs are frequent; and the system has only slight power to resist disease of any kind. The whole condition is one of **oxygen starvation** and **carbon dioxide poisoning**.

The Proper Amount of Air. — The supply of fresh air required for a room depends largely on the number of persons in the room; for it is evident that a hundred persons will require a hundred times as much air as one person.

Then, too, the presence of fires in the room must be considered. The burning gas consumes much oxygen and

gives off carbon dioxide. For this reason a crowded hall, on a cold winter's evening, with heavy fires and lighted gas, requires much more ventilation than when a small company is assembled on a warm summer's day. As it would cause discomfort to raise the windows and open the doors during the winter time, it follows that some **system of ventilation** is absolutely necessary for all places where persons are likely to assemble.

Heating and Ventilation. — How to obtain an unfailing supply of fresh, outdoor air in our rooms is the constant study of those who plan homes and public buildings. Years ago this subject received no attention whatever. This was partly due to the fact that the method of heating the houses was far different from that used at the present day. The open fireplaces made a constant change of air, while the cracks about the doors and windows furnished avenues through which the fresh air entered the rooms.

A **furnace** gives good ventilation, because as the warmed outside air enters the room from the registers, some of the air already in the room will find its way out through the ventilators or through the cracks; thus a constant current of air is established. Great care should be exercised to see that the cold-air flue of the furnace receives its supply from out doors, not from in doors. If the outdoor air entering the flue passes over decaying animal or vegetable matter, or an imperfect sewer, then the impure air may be conveyed into the building, producing severe and perhaps fatal sickness.

If the rooms be heated by a furnace, the air should be moistened by having it pass over a dish of water. Failure to do this results in the necessity of breathing very dry air, which is decidedly injurious. The **open grates** of modern days are good ventilators. An **ordinary stove** is

a means of ventilation, for as the draught passes through it and up the chimney, fresh air comes in through the opening of doors and the crevices of the windows to take its place.

Ventilation of the Sleeping Rooms. — Attention should always be given to the ventilation of the sleeping rooms. One third of our entire lives is spent in these rooms, yet how often do we neglect to make them either cheerful or healthful. If the builders of the house have not provided some method of ventilation, the air may be changed by raising the lower sash of one window and lowering the upper sash of another. If there is but one window in the room, it should be lowered from the top. A better method, however, is to admit the air into the room through wire gauze, used as window screens. There are a number of ventilators for sale in the market which allow a free passage of air and yet effectually prevent draughts.

If the lower window sash be raised about six inches and a board be placed under it, completely filling the space between it and the window casing, some ventilation will be established between the sashes. This is a fairly good method for the winter, but hardly sufficient for the more quiet air of summer.

Some persons seriously object to opening the windows of their sleeping rooms at night, for fear of "the deadly night air." Yet all the lower animals breathe it, from the delicate and tender young to the strong and the aged. Soldiers and hunters breathe it as they sleep beneath their tents and in the open air, while many invalids have been restored to health by living out of doors both day and night.

The bed should be well aired each day. Immediately after dressing, throw the upper clothing of the bed over

a chair, raise high the windows in the room and allow the clothing to become well aired for an hour or two at least before it is placed on the bed again. Indeed, a very good rule to remember is this: Clothing worn during the day should be aired at night, and clothing used at night should be aired in the daytime, preferably in the sunlight.

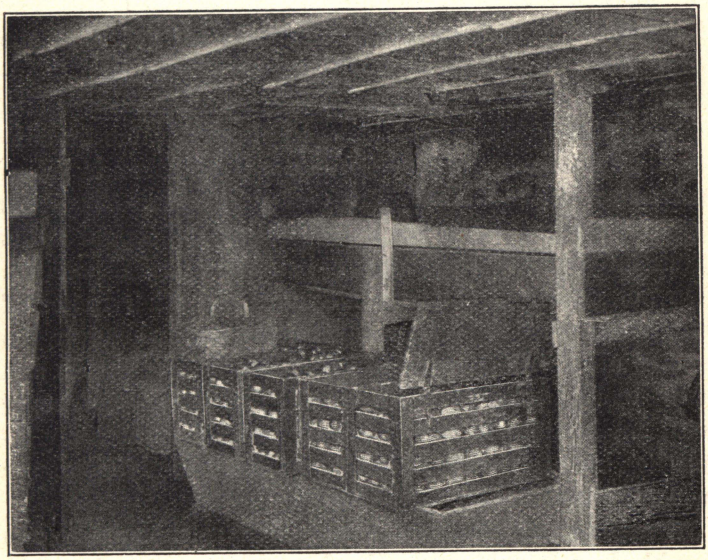
Ventilation of the Schoolroom. — The teacher generally gives personal attention to the ventilation of the schoolroom, and the proper authorities should see to it that some method is devised by which the change of air may be constant and abundant. This does not mean ventilation at noon and recess only ; it means that the change should be continuous and uninterrupted, for anything short of this fails to answer the purpose.

After the hearty plays of recess, when the skin is moist with perspiration, the pupils should not sit down in a cool room. This is too often the cause of colds and coughs. The schoolroom should be of an even temperature all through the day ; therefore there must be a constant and uninterrupted change in the air. Ventilation is improper if it produces a current of air ; for if a draught of air be allowed to strike the back of the neck, or any sensitive part of the body, it is very likely to cause a cold. These currents of air should be carefully avoided, especially when the body is resting after active exercise.

Ventilation of the Cellar. — The cellars of houses and other buildings are often great reservoirs of foul air. The cellars of dwellings frequently have stored in them quantities of vegetable matter which give off injurious gases as they decompose. As the cellar is usually dark, the decaying organic matter is unseen, and hence it remains until the escaping gases penetrate the rooms above, and endanger the health of the inhabitants. Cel-

lars should be well ventilated, kept scrupulously clean, and so built, if possible, that the sunlight can enter them.

Deodorizers. — One odor may cover another without destroying it. A free use of cologne may cover the odor of a poorly ventilated room, but it will neither remove the carbon dioxide and the organic matter, nor bring more



WELL-ARRANGED VEGETABLE BINS

oxygen. Coffee and sugar are often burned in a room to destroy some disagreeable odor. They do not destroy, however; they simply cover one odor with another more powerful. Any substance that will replace or cover the odor of another, and yet not destroy it, is called a **deodorizer.**

Disinfectants. — There are substances which actually destroy odors; these are true **disinfectants.** They are

used to purify sewers, cesspools, and sinks, and to destroy the germs of scarlet fever, diphtheria, and smallpox. A disinfectant may be perfectly odorless itself, and yet have the power of destroying the most offensive odors. The **chlorides** and **sulphates** of the metallic salts are powerful disinfectants. Preparations of the chlorides are on the market which are reliable and convenient. The sulphate of iron (copperas) dissolved in water in the proportion of four ounces to the gallon, is a useful disinfectant for cleansing gutters, drains, sewers, etc.

Sunlight. — We cannot place too high a value on sunlight; the strong rays of the sun are sufficient in themselves to destroy many forms of germ life. There is great cleansing power in sunlight, and we should let it pour into our sleeping room for hours at a time if possible. Do not be afraid of the sunlight in the other rooms of the house. At some time during the day, whenever the rooms are so situated as to make it possible, let the sun send in its health-giving power. The wise housekeeper will not hesitate to risk the fading of the carpets, appreciating how fortunate it is that such a life-giving power as sunlight can enter the home.

Sweeping and Dusting. — It may seem as though any one could do properly such simple work as sweeping and dusting. We must recall, however, that dust is not simply dirt, but may contain many harmful disease germs. If these cannot be removed, they certainly ought not to be kept floating in the air. It is important therefore to sweep thoroughly, yet gently; to sweep the floor or carpet clean and yet raise but little dust. It is better, when the furniture will allow, to use a slightly dampened cloth for dusting; the usual way of dusting often means simply the removal of the dust from one part of the room to another.

Heavy draperies and curtains should be frequently taken out of the house and thoroughly shaken or dusted.

Boys should remember that it is not the kind and manly thing to do to come into the house with dirty boots or shoes, or with the clothing all covered with snow. Clean the boots and shoes and brush the clothing before entering the living rooms.

Back Yards. — People who keep their front yards in fine condition sometimes thoughtlessly neglect the back yard. It should be kept free from refuse material of every kind. Water should not be allowed to stand in tubs or barrels, and thereby become the breeding place of mosquitoes. Pools of water should not be allowed to exist there any more than in the front yard. Another reason why the back yard should be kept tidy and free from all decaying material is because the windows from some of the sleeping rooms of the house usually open directly toward this yard.

Contagious Diseases. — The air we breathe may seem to us to be very pure because it is free from any odor, and yet it may contain the germs of very contagious diseases. By contagious diseases, we mean a disease that can be carried from one person to another. The germs of such diseases as diphtheria and scarlet fever are easily carried by means of the clothing, or even in the dust of the atmosphere. A person does not necessarily have the disease to which he has been exposed; but it is always best to be very careful. The one who is ill with any contagious disease should be kept in a well-ventilated room, and no members of the family admitted except the mother or nurse.

Boards of Health. — If every person knew the importance of regarding the laws of health and would carefully follow them, no police regulations would be required; but this is not the case. Hence nearly every state, nearly

every city, and nearly every village has its Health Commissioner or Board of Health. Over two hundred years ago the famous Izaak Walton said, "That which is everybody's business is nobody's business"; this is true even to-day. Therefore, it becomes necessary that one person, the Health Officer, or a few persons combined, the Board of Health, should watch over the health of the community, and look out for those things which, since they affect the community as a whole, might otherwise be left by each person for the next person's attention and care. These health officials are expected, for instance, to see that the school buildings are well ventilated, that the drinking water supplied for the pupils is pure, and that proper protection is given if there are any contagious diseases among the children. They also watch the supplies of foods in the markets, in order that decayed or overripe fruits and vegetables and tainted meats may be destroyed. Boards of Health should also regulate the removal of garbage and waste, should see that houses are provided with proper drainage, and should, in a word, have the health of the whole community at heart.

CHAPTER XIII

THE KIDNEYS

General Description. — The kidneys are two in number, one on each side of the spinal column. The lower edge of each comes just above the waist line. Each kidney is about four inches in length, two inches in breadth, an inch in thickness, and about five ounces in weight.

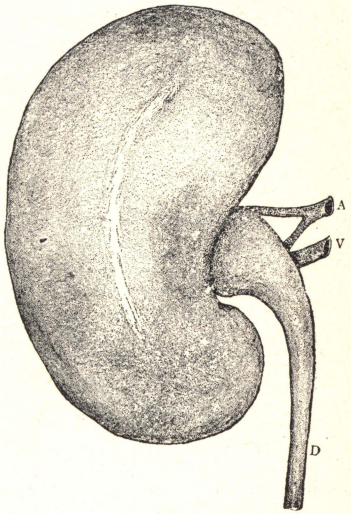


FIG. 41. — A kidney: A, an artery; V, a vein; D, the duct that carries away the materials filtered from the blood.

A kidney resembles a bean in shape. The rounded edge of each kidney is placed toward the side of the body, while the hollowed edge is next the spinal column. The kidneys are completely covered with a thin membrane, called the **capsule.** Each kidney is supplied with blood by an artery which arises from the aorta. This artery enters the kidney as shown at A, Fig 41. After the arterial blood has circulated through the kidney, it is returned through a vein at V. This vein empties into the large vein which lies by the side of the aorta.

Minute Structure. — The most interesting portion of the kidney is found in that part near the rounded outer edge, to the left of Fig. 42. Here active changes are constantly taking place. In this portion there are seen, with the microscope, vast numbers of small, round, red bodies, which are but the beginnings of long, narrow tubes. Each body consists of coils of capillary blood vessels, surrounded by a membrane. While the blood is circulating through the kidneys, certain substances are taken from the blood. These substances are carried away through the minute canals of the kidney (the fine, fan-shaped lines) until they empty into a large duct, shown at (7) and (8), Fig. 42. This duct carries the secretion directly to a reservoir, designed especially for its reception, called the bladder.

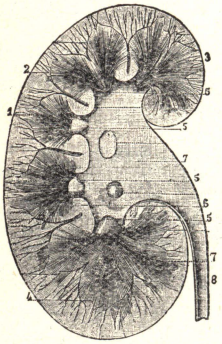


FIG. 42. — A section through a kidney: (1, 2, 3, 4), collections of tubes, or canals; (5), papillæ on which the tubes open; (6), below the end of the dotted line is a blood vessel; others are seen above this; (7), the dilated beginning of the duct (8), which carries the secretions from the kidney.

Secretions of the Kidneys. — When the blood reaches the kidneys it contains one substance in particular which must be removed from the body or most serious results would follow. This substance is called urea; it is held in solution by the water that composes such a large part of the blood. Urea contains nitrogen which was supplied to the body as a part of the nitrogenous foods; at this stage, however, it is no longer of any worth or use to the body, for it is a waste product. The muscles contain nitrogen, and as they work they wear out; the nitrogen which is in the

urea represents a certain amount of worn-out muscular tissues. Urea also comes from other worn-out tissues that contain nitrogen, such as the various glands of the body. It is therefore an excretion, something which must be removed from the body, hence the kidneys are called excretory organs. A great part of the nitrogen which we take into the body with our food is at last removed from the body by the kidneys in the form of this urea.

The water secreted by the kidneys holds many other substances in solution besides urea. If the kidneys from any cause should completely fail to perform their work, life could exist for only a few hours. Should they but partially perform their work, then the other organs of excretion would be called upon to do extra work. For a time they might do so, but soon they would suffer from the overwork and serious results would follow.

The work of the three great excretory organs — the lungs, the skin, and the kidneys — is so carefully adjusted that each has its own particular duties, yet all work in perfect harmony.

Danger from Use of Alcoholic Drinks. — The use of alcoholic drinks is considered by some physicians to be a serious cause of various forms of kidney trouble. It may be a direct cause, through its irritating effects, or an indirect one by causing the liver to become diseased and unable to perform its functions. In the latter case, the poisons that the liver should take from the blood pass on to be thrown out by the kidneys. The result may be either the overworking of the kidneys or the irritation of them from an abnormal amount of poison, or both.

CHAPTER XIV

THE BONES

General Description. — There are two hundred and four distinct bones in the body. This does not include the teeth, the knee pan, and a few other bony structures. When the bones are for the purpose of protecting delicate parts they are generally broad and flat — as the bones of the skull and shoulder blade. When strength and lightness are both desired, as in the large bones of the arms and legs, the bones are then round and hollow.

The Periosteum. — A thin membrane, called the **periosteum**, surrounds each bone. It is composed of two layers, an outer layer of firm tissue, which is simply for support and protection, and an inner layer of cells. This inner layer is essential to the life of the bone, and its cells are even capable of forming new bone.

The periosteum is well supplied with blood vessels, some of which pass directly into the bone through minute openings on the surface. These openings can be seen on any bone from which the periosteum has been removed.

Compact and Cancellous Tissue. — If one of the long bones of any animal be sawed lengthwise, it will be found to be hollow, except at the ends. The hard, thick wall, midway between the ends of the bone, is called the **compact tissue**; while the spongy, honeycombed bone, occupying the center of the ends of the bone, is called the **cancellous tissue**. See Fig. 43. The smaller bones

and the flat bones are not hollow; they have an outer layer of compact bone, within which is the spongy bone, or cancellous tissue.

The Marrow. — The large central cavity of the long bones, and all the spaces in the spongy bone, are filled with a yellowish or reddish substance, called **marrow**. It consists principally of fat cells and marrow cells. These marrow cells doubtless give rise to large numbers of the red corpuscles of the blood.

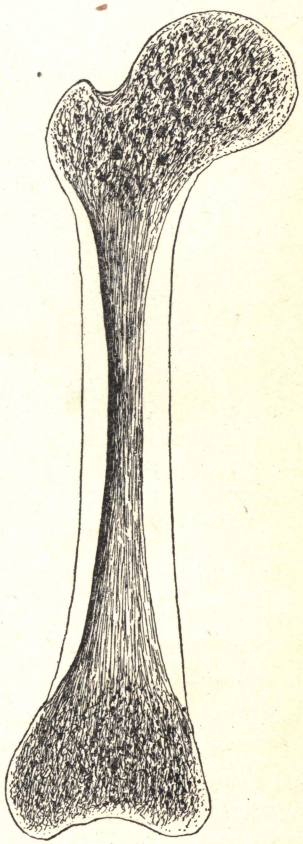


FIG. 43. — Longitudinal section of the femur. The spongy or cancellous bone shows at the ends; while the compact, hollow bone forms the shaft.

Animal and Mineral Matter. — The blood vessels, bone cells, marrow, nerves, and the framework of fibers, constitute the **animal** matter of bone. This makes the bone soft and yielding. But the body must have a stronger protection and support than this. We find, therefore, that some **mineral** substance is added to the animal matter, making the whole tissue of the bone firm and hard.

By remembering that fire will destroy animal matter and that acids will dissolve mineral matter, some interesting results may be obtained. For instance, if the fresh bone of a chicken or of any animal be placed in the

fire, and subjected to heat for a considerable time, all the animal matter can be burned out. The shape of the bone will not be changed ; it will only become lighter and whiter. After such treatment it can be easily broken and pounded into a fine powder.

The mineral matter consists largely of lime. This can be removed by soaking the bone in a weak acid for a

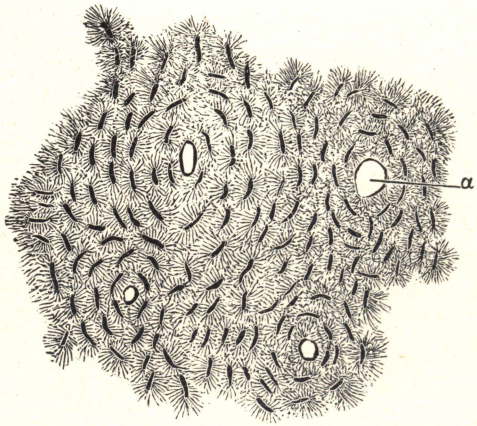


FIG. 44. — Cross section of bone, not so highly magnified as Fig. 46. Canals (*a*) for blood vessels are seen cut crosswise. The spider-shaped cavities for the bone cells are also seen.

few hours. The shape of the bone will not be changed ; it will only lose its hardness, and may be easily bent in any direction. All the blood vessels and the bone cells still remain in the bone (Figs. 44, 45, 46).

From these experiments we easily draw the conclusion that, if the bones do not contain the proper amount of mineral matter, they will bend, and will be unable to keep their shape and properly support the tissues around them. If there is a deficiency in the amount of animal matter,

the bones will be too brittle, and liable to break if any extra strain be brought upon them.

Nature very wisely provides that in early life there should be an excess of the animal matter in bone. If this were not so, the tumbles and falls which are the common lot of all children at play would result in many serious injuries. But the bones of youth have such a spring to them that children are not likely to fracture them. In old age the bones are very brittle, and are much more easily broken.

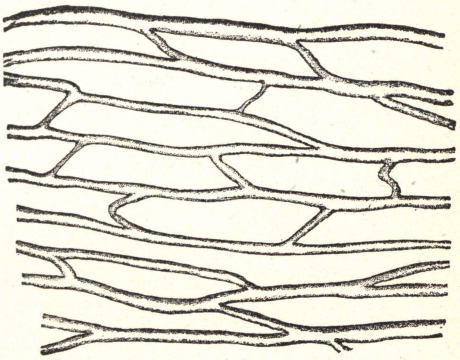


FIG. 45. — Longitudinal section of bone; showing the bone canals, magnified.

Broken Bones. — When a bone is broken, the surgeon places the broken ends together, and holds them in position by means of splints and bandages. Nature immediately begins the work of mending the bone. First, a liquid substance surrounds the broken ends. This gradually becomes firmer and harder, and in a few weeks develops into true bony structure. Thus the ends become so firmly united that the bone is as strong as ever.

Changes in Bone. — The bones are not fully developed until one is at least twenty-five years of age. And it should be remembered that even after this, they, in some degree, change their soft substance. When the bones have an abundance of animal matter, as in early life, they can be molded, and their natural form greatly changed. This is well illustrated by the Chinese custom of binding

the feet of their young girls until an unsightly deformity is produced which often results, later in life, in pain and disease in these parts.

Young children or infants should not be placed continually in one position, and when very young, they should not be allowed to remain too long in the sitting posture. If they are made to sit or to stand too early, the bones may be bent or changed so as to interfere with their proper development. In caring for children, we must constantly remember how tender and easily bent are the growing bones which form the solid structures of the young bodies. Otherwise the child may become bow-legged, or may sustain some other, but perhaps less evident, change from the normal shape of the bony structure.

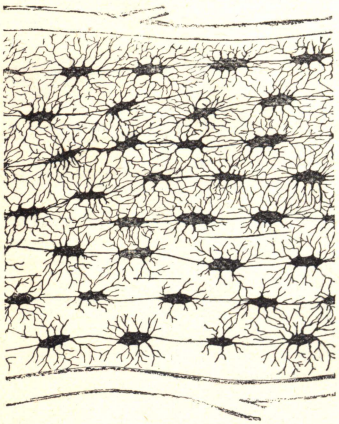
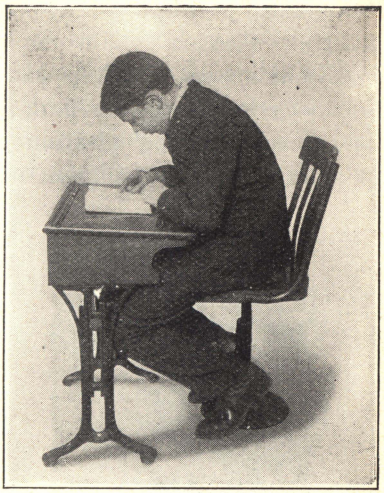


FIG. 46. — Longitudinal section of bone, highly magnified. A blood vessel is seen at the top, another at the bottom. In living bone, the spider-shaped cavities here shown are filled with bone cells. Thus we learn that bone is a living tissue.

A Good Figure. — A fine erect figure generally gives evidence of a healthy body and of a mind that is alert and well poised. Young children who are strong and well usually stand erect and are graceful in their motions. Too often they lose this erect figure as they grow older, and form bad habits in sitting and in standing, when at work and play. Then the balance and symmetry of the figure must be restored by a series of exercises that shall develop the muscles which have been weakened by con-

stant bad position. When the student is absorbed in studying, it frequently happens that the body is allowed to droop more and more until finally it is in a crouching position. In this way the chest is narrowed, the circulation hindered, and the student cannot breathe properly.

A correct reading position at a desk is shown below. Among the bad positions frequently taken by careless students, one of the most common is shown by the illustration above. In this case, too, the harm is intensified by the fact that the desk and seat are too low for the student. The study chair and table used at home, as well as the desk and seat used in the schoolroom, should be made to fit the body properly, even if some pains has to be taken to secure the right adjustment.



AN UNNATURAL POSITION, CRAMPING THE LUNGS AND DIGESTIVE ORGANS AND INTERFERING WITH THE FREEDOM OF THE CIRCULATION.

A CORRECT AND COMFORTABLE POSITION FOR READING AND STUDY.

It is not in studying alone that one frequently

takes a bad position. Many people have a habit of resting in attitudes that are even worse for the body. Some of these positions are so injurious and so commonly taken that it seems desirable to show here for comparison a comfortable and restful sitting position and some of the incorrect positions that are frequently assumed. The lines under

THIS POSITION SHOWS A COMFORTABLE AND RESTFUL WAY OF SITTING, WITH MUSCLES RELAXED. THE SPINE IS PROPERLY SUPPORTED AND THE BODY IS WELL POISED.

THIS POSITION IS NEITHER A GRACEFUL NOR A RESTFUL WAY OF SITTING. IT TENDS TO PRODUCE ROUND SHOULDERS, AND IT INTERFERES WITH THE FULL AND FREE ACTION OF THE LUNGS.

the illustrations call attention to some of the injuries resulting from those wrong positions in sitting which are shown. Ask some one who has made a study of physical training to explain more fully why these positions are harmful. We should avoid many such faults if we realized that it is not well to rest one part of the body by throwing unnatural work on the other parts. Notice how this applies to the incorrect positions as here illustrated,

and how comfortably the body is poised for resting in the correct sitting position, as shown on page 128.

In standing, it is better to rest the weight on both feet. The habit of resting the weight on one and the same foot is sure to make the hip bones grow out of shape ; it will also bend the spine, and make it incline toward one side.

THIS POSITION HAS MANY OF THE SAME FAULTS AS THOSE NOTED IN THE PRECEDING ILLUSTRATION ; AS A RESTING POSITION, IT IS EVEN MORE OBJECTIONABLE.

THIS POSITION IS FREQUENTLY TAKEN WHEN RESTING. IF ONE HABITUALLY SITS IN THIS WAY, THE BODY IS QUITE LIKELY TO BECOME DEFORMED.

In walking, the whole body should be erect, with the chin held in and the chest held high. If the body does not take this position naturally and easily, it is because we have allowed ourselves to become careless and to form bad habits, which we must correct.

CHAPTER XV

THE SKELETON

Object of the Skeleton. — All the higher animals are provided with a bony support, or framework, for the organs and tissues of the body. This framework is called the **skeleton.** It serves also as a protection from injury. In some of the lower animals, the skeleton is entirely on the outside. The oyster is completely inclosed in its hard shell, and is thus well protected against the attacks of enemies. The lobster has an exterior skeleton also, but the parts are so arranged that there is considerable freedom of motion. The turtle has not only an interior skeleton, but also a large plate, or exterior skeleton, of hard material. This animal can withdraw its head beneath the outer skeleton, and thus the whole body is protected from violence.

The animals which have exterior skeletons do not have such freedom of motion as is required by the higher animals. Therefore, in man, beasts, birds, fishes, and some other animals, the skeleton is entirely within the body. The ribs, spinal column, and breast bone make a nearly complete covering for the heart and lungs.

The Bones of the Skull. — The head is composed of twenty-two bones. Eight of these make a solid, strong covering for the brain, while fourteen compose the bones of the face. At the base of the brain is a large opening through which the spinal cord and a number of large blood vessels pass. (Study Plate V for location of bones.)

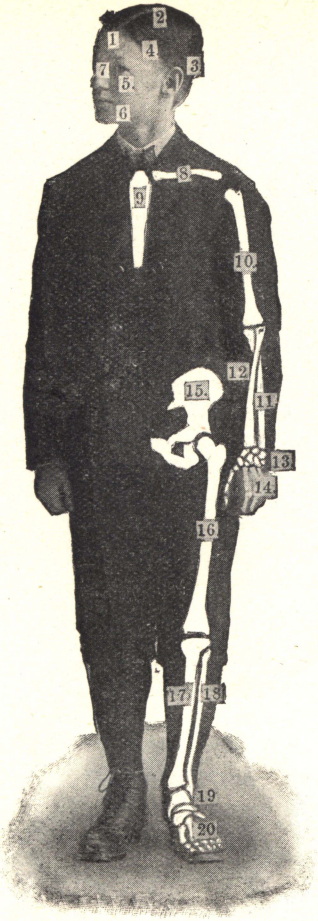


PLATE V

The names and locations of the principal bones of the body: (1) frontal; (2) parietal; (3) occipital; (4) temporal; (5) superior maxillary; (6) inferior maxillary; (7) nasal; (8) clavicle; (9) sternum; (10) humerus; (11) ulna; (12) radius. Notice that the radius has crossed the ulna. When the hand is turned so that the thumb is outward (not inward as here represented), and the palm of the hand is to the front, then the radius is all on the outward side, and lies parallel to the ulna. (13) Small bones of the hand; (14) bones of the fingers; (15) pelvic bones; (16) femur; (17) tibia; (18) fibula; (19) small bones of the foot; (20) bones of the toes.

The frontal bones, one on each side, form the forehead. Two bones, the parietal, one on each side, form the top or crown of the skull. The bone at the back and lower part of the skull is the occipital bone; and the opening through this bone allows the spinal cord to pass to the brain. There is one bone on each side of the skull called the temporal bone. Directly back of each ear is a portion of this bone called the mastoid. This is of especial interest because in certain diseases of the ear it becomes seriously affected.

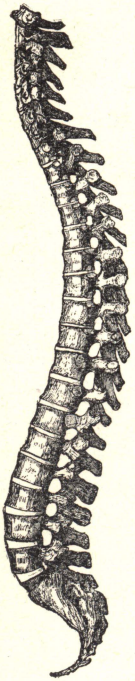


FIG. 47. — The spinal column. The right side of the figure is toward the back of the body.

The superior maxillary bones, the upper jaw bones, are the large bones which form the whole of the upper jaw. They also form the bony roof of the mouth and the bony framework for the upper part of the cheeks; the upper teeth are inserted in these bones. The inferior maxillary or lower jaw bone is the largest and strongest bone in the face; in it the lower teeth are located. The nasal bones are two in number and are placed at the upper part of the nose, forming the "bridge" of the nose. The lower part of the nose consists of cartilages and soft tissue.

The Spinal Column. — The **spinal column** consists of twenty-four small bones, — resembling those illustrated at Figs. 49 and 50, — and two irregular bones at the lower end of the column.

A reference to Fig. 47 shows that the spinal column is not straight, but forms a series of curves. These curves give additional elasticity to the column.

Each bone in the spinal column is called a **vertebra**, from a Latin word signifying "to turn," as a joint. Thus a translation or definition of the word would be, "a joint of

the spinal column." Each vertebra has within it a large opening, through which passes the *spinal cord*. The vertebræ are held together by **ligaments**, and are so placed, one directly over the other, that the central openings form a continuous canal extending the entire length of the spinal column. This is called the **spinal canal**; it furnishes a firm protection to the spinal cord. Between the vertebræ, as shown in Fig. 48, are disks, or cushions of elastic **cartilage**. This cartilage resembles rubber in its elasticity. Its great use can be appreciated when it is stated that the combined thickness of all these cushions is over six inches. They greatly diminish the shock and jar that come to the body from jumping and running.

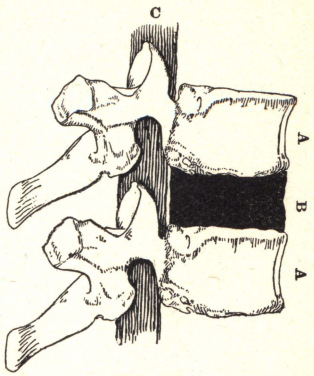


FIG. 48. — Two vertebræ, A, A, slightly separated to show the cushion of cartilage, B; the position of the spinal cord is indicated at C.

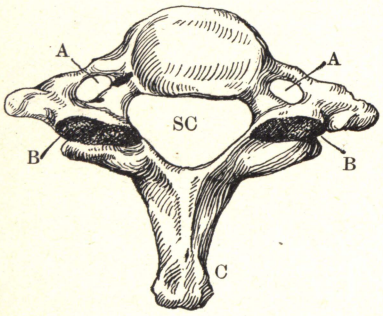


FIG. 49. — The upper surface of one of the vertebræ of the neck: A, opening in each side for a blood vessel; B, point on which the bone above it rests; C is the long process that extends from the back of the spinal column; SC, opening in the center for the spinal cord.

Nearly all the vertebræ resemble those shown in Figs. 49 and 50. Fig. 49 illustrates a vertebra of the neck, as viewed from above. The long process, C, is the one that is so easily felt at the back of the neck. The darkly

shaded oval portion at the top of the figure, immediately in front of the opening for the spinal cord, is the place of attachment of the elastic cartilage. Fig. 50 represents a vertebra lower down the spinal column, and viewed from the side. At A is represented the front of the vertebra, and the place where the cartilage is attached. The long process, B, extends backward and downward, forming a part of the ridge, which may be felt extending down the center of the back.

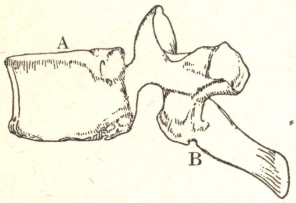


FIG. 50. — One of the vertebræ viewed from the side: A, represents the body of the vertebra; B, the process.

The "**atlas**" is so named because it supports the globe of the head. It stands at the top of the spinal column, and differs in shape from the other vertebræ. Upon this bone, which remains stationary, the skull rests, nodding, or moving backward and forward, at will.

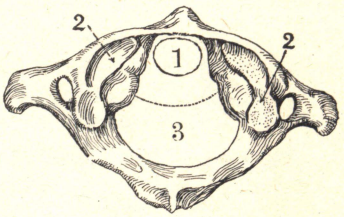


FIG. 51. — The atlas, or the first vertebra, viewed from above: (1) the process of the axis; (2) the places on which the skull rests; (3) the opening for the spinal cord. The dotted line represents a ligament which holds the process (1) in place.

The "**axis**," or second vertebra of the spinal column, is so named because it forms the pivot upon which the head turns from side to side. This pivot is the strong bony projection, resembling a tooth, which rises perpendicularly from the upper and front part of the axis. When the atlas and the axis are in position, they correspond to Fig. 53. During the sidewise movement of the head, the skull and the atlas move together, the atlas swinging around the

pivot of the axis. A study of Figs. 51, 52, and 53 will aid in making this clear.

The Ribs. — There are twelve **ribs** on each side of the body. The ribs are so curved that each makes an elastic arch of bone. Behind, the ribs are attached to the spinal column. In front, the first seven are attached to the breast bone by means of cartilages. The next three are fastened to each other by cartilages; while the last two have no attachment in front, hence they are called the floating ribs.

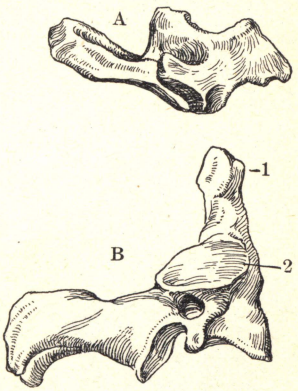


FIG. 52. — The atlas (A) and the axis (B) viewed from the side: (1) the process on which the atlas turns (seen also at 1, Figs. 51 and 53); (2) the place on which the atlas rests.

The Thoracic Cavity. — The **thoracic cavity**, so called because it contains the **thorax**, or chest, is inclosed by the spinal column behind, the **sternum**, or breast bone, in front, the ribs on the sides, and the diaphragm below. The spaces between the ribs are filled in with muscular tissue, so that surrounding the thoracic cavity there is a complete wall, formed partly of bone and partly of muscle. All that part of Fig. 39 which is above the diaphragm, (6), represents the thorax. In this cavity are the lungs, heart, and large blood vessels.

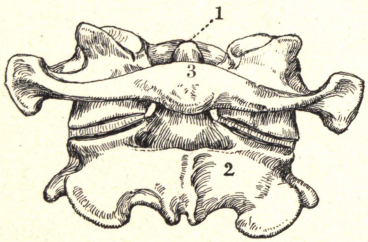


FIG. 53. — The atlas and axis in position, front view: (1) the toothlike process of the axis, showing above the atlas; (2) the axis; (3) the atlas.

The Upper Extremities. — There are five large bones and several small ones that belong to the arms, the upper extremities of the body. The **clavicle**, or collar bone, extends from the front of the shoulder to the top of the sternum ; it keeps the shoulders from stooping. The **scapula**, or shoulder blade, forms the back of the shoulder, between the shoulder joint (Fig. 54) and the spine. At its upper and outer part is a cavity, or socket, for the reception of the head of the **humerus**, or upper arm bone, which extends from the shoulder to the elbow. The two bones

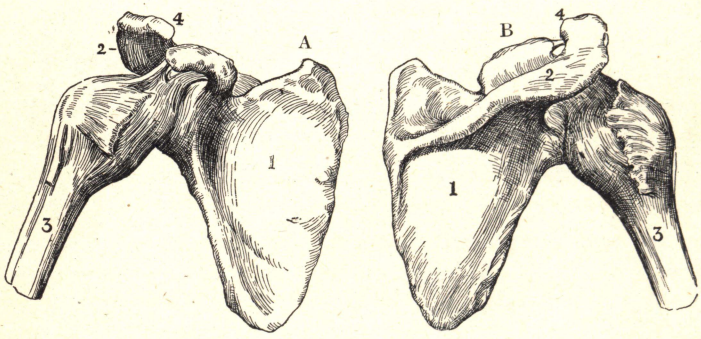


FIG. 54. — A, Front view of the right shoulder joint, without collar bone. B, Back view of the same joint.

(1) Scapula; (2) bony prominence on scapula; (3) humerus; (4) point of attachment of collar bone. The ball (head) of the humerus is held tightly to the socket of the scapula by means of the ligaments here shown.

of the forearm, or lower arm, are the **radius** and the **ulna**. The radius and ulna are placed side by side, and so arranged that the radius can move partly around the ulna, giving the hand the power of rotation, or turning. The radius is on the side of the arm corresponding with the thumb. The remaining bones of the arm form the hand.

The Pelvis. — The **pelvis** is a kind of bony basin inclosed, on the back, by the two lower bones of the spinal column ;

on the sides, by the large hip bones (Fig. 55); and in front, by the pubic bones. The curved shape of the upper edge

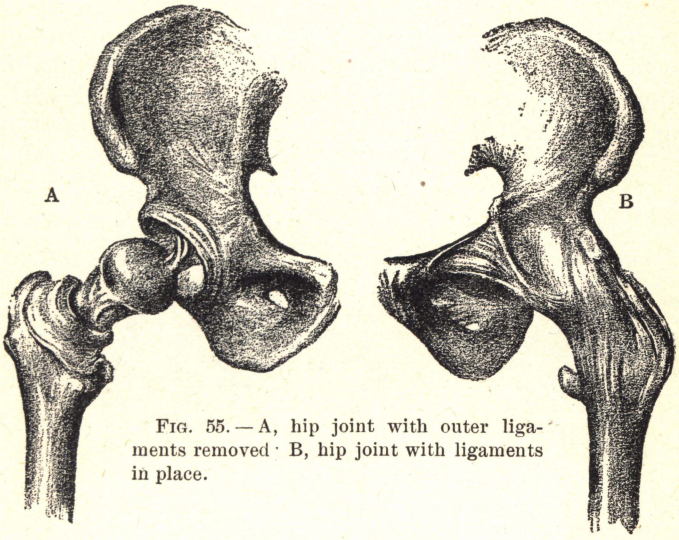


FIG. 55. — A, hip joint with outer ligaments removed · B, hip joint with ligaments in place.

of the hip bones gives a strong support for the abdominal organs. The sides furnish a means of attachment for the legs, while the back gives attachment to the spinal column.

The Lower Extremities. — The **femur**, or thigh bone (Fig. 56), extends from the thigh to the knee; it is the

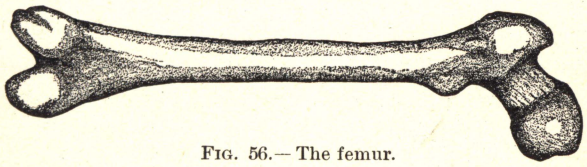


FIG. 56. — The femur.

longest, largest, and strongest bone in the body. The **tibia** and **fibula**, placed side by side, form the lower part of the leg. The tibia forms the ridge in the front of

the leg, while the fibula forms the outside of the leg. The **patella**, or knee pan, protects the knee in front.

Bones of the Foot. — The bones of the foot are so united that they form an arch (Fig. 57), of which only the ends touch the ground. This arch is useful in protecting the body from severe shocks, as in the act of running or jumping; for it is evident that when the weight of the body is

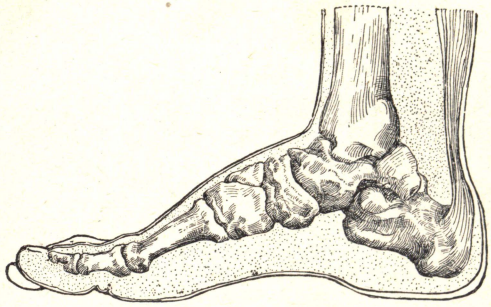


FIG. 57. — Side view of the bones of the foot, naturally arranged in the form of an arch.

thrown upon the arch, its center is pressed downward, thus acting as a spring.

The Joints. — Whenever bones form a **joint**, or meeting place, they are covered with a layer of highly polished cartilage (Fig. 58). This gives some slight elasticity, and also reduces the friction. Covering the cartilage is a very thin membrane which is constantly secreting, or pouring out, a watery fluid, called the **synovial fluid**, or joint water. It serves the same purpose as does oil on the wheels and joints of machinery.

The Ligaments. — The bones are held together at the joints by bands of tissue, called **ligaments**. These are very dense and strong, and capable of withstanding great

strain without injury. Fig. 55, B, illustrates how the head of the femur is buried in the socket prepared for it; Fig. 55, A, illustrates the hip joint after the outer ligaments have been removed, and the bone pulled partly out of its socket. A strong ligament still remains, holding the head of the femur to the center of the socket.

Sometimes the ligaments are unduly stretched, or slightly torn, as when the wrist or ankle is **sprained**. Such an injury usually causes great pain, and recovery is slow. The ligaments may be so broken or torn that the bones slip out of their proper places. The bone is then said to be "out of joint," or dislocated. Sometimes in healthy persons the ligaments are very loose, so that, by the action of the muscles alone, some of the joints can be dislocated at will. Such persons are said to have loose joints.

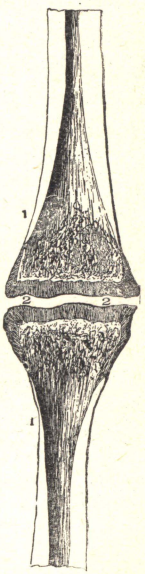


FIG. 58. — A longitudinal section through a joint, showing a layer of cartilage over the end of each bone: (1) the bones; (2) the layers of cartilage.

Varieties of Joints. — Joints may be either **movable**, **imperfect**, or **immovable**. The **movable** joints, such as the shoulder and elbow joints, vary exceedingly in their power of motion. The **imperfect** joints are such as are found in the spinal column. There is some slight motion between the vertebræ, due to the elasticity of the thick plates of cartilage. It is the same motion that can be made after cementing a thick plate of rubber between two blocks of wood. The elasticity of the rubber would allow a certain freedom of motion and yet

the parts would not move upon one another. Examples of the **immovable** joints are seen in the union of the bones of the skull. The edges of the bones are so fitted into each other that they form an unyielding joint, or suture. Because of the delicacy of the brain it is important that the covering should be firm and unmovable.

The Ball-and-socket Joint. — When the head of one bone, which is more or less round like a ball, fits in the socket, or depression, of another bone, the joint is called a **ball-and-socket joint.** The bone with the round head can move in any direction, the extent of its motion depending only upon the shape of the socket. If the socket be deep and small, as in the hip, the motion will be limited, but if the socket be shallow and broad, as in the shoulder, then the motion will be free in every direction.

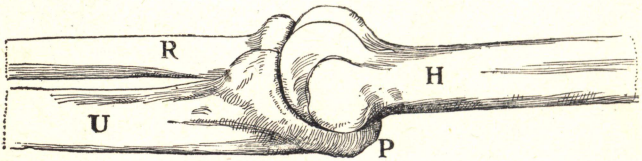


FIG. 59. — A section through the elbow joint: H, the humerus; U, the ulna; R, the radius; P, the process, which prevents the arm from moving back of a certain line.

Hinge Joints. — When two bones are joined together so that they can move back and forth in only one direction, like the hinges of a door, the joint is called a **hinge joint.** The elbow is the best example of a hinge joint (Fig. 59). The movement is limited, for while the arm can be bent forward and straightened, it cannot be bent backward. The knee is another example of this joint.

Pivot Joints. — The rotary motions of the head, by which the skull and the atlas turn upon the pivot of the **axis,** furnish an illustration of a **pivot joint.**

CHAPTER XVI

THE MUSCLES

General Description. — The great bulk of the body, outside of the skeleton, is composed of **muscles.** The muscles give the general outline to the body and make nearly one half its total weight. Nearly all the muscles are arranged in pairs, so that the two sides of the body are almost alike. Some of the muscles are very minute, while others are long enough to reach from the hip to the knee. In the majority of animals, they are of a deep red color, forming the lean meat or flesh. In many of the fishes and in some of the birds, the muscles are white, or of a light yellow color.

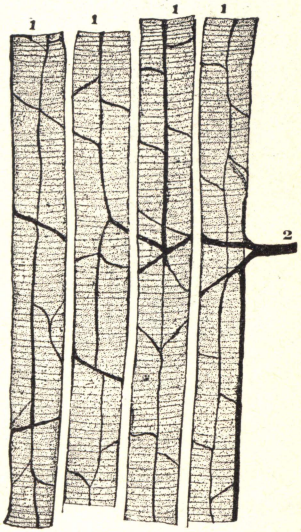


FIG. 60. — Voluntary muscle, with its blood vessels: (1) the muscle fibers; (2) the blood vessels, magnified.

The Uses of Muscle. — The muscles are primarily the organs of motion. They also act as a protection to the blood vessels and the nerves; they inclose the large thoracic and abdominal cavities; they serve as cushions to diminish the force of falls and blows; they fill up irregularities in the skeleton, and thus add to the symmetry of the whole body.

Two Kinds of Muscle. — The muscles are, in respect to their duties, divided into two classes, the **voluntary** and the **involuntary**. The **voluntary** muscles are so called because their movements are under the control of the will. Such muscles can be used whenever we wish or will to use them, as the muscles of the face or the arm. Others cannot be controlled in this way; they do their work independent of any action of the will, hence they are called **involuntary**. The muscles of the stomach and the heart are of this variety. The heart beats, the stomach contracts, and we are powerless to stop their action.

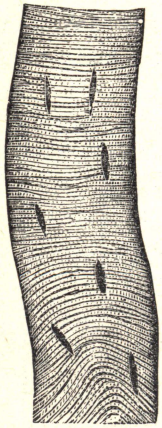


FIG. 61. — A muscular fiber, magnified.

As a rule, all those movements in the body most essential to life are not under the control of the will. Yet many of the involuntary muscles can be controlled for a short time. An illustration of this is found in ordinary breathing. We breathe a certain number of times a minute and are entirely unconscious of it; still, by an effort of the will, we can breathe faster, slower, or deeper. Even the voluntary muscles can be made to contract involuntarily by a sharp blow, or by some fright. While voluntary muscles, therefore, are controlled by the will, they are not invariably so controlled. Nearly all the voluntary muscles are attached to bone at each end; while the involuntary are not attached to the skeleton, but are found in the walls of hollow organs, as the stomach and the intestines, and in the walls of the arteries.

Structure of Voluntary Muscle. — If a piece of lean meat,

which is voluntary muscle, be boiled, it will appear as if ready to fall apart into little bundles of tissue. These bundles may be easily divided into still smaller ones, by separating them carefully with needles. In this way minute threads of tissue are obtained. If one of these be examined with a microscope, it will be found to consist of many smaller threads, called **muscular fibers**. In Fig. 60, four of these fibers are seen side by side, with their accompanying blood vessels. In this figure, and also in Fig. 61, fine lines may be noticed running directly across each fiber. Because of these markings, this variety of muscle has been called **striated** muscle. Notice the blood supply, as shown in Fig. 62. On examining any piece of lean meat, the bundles are seen as strings of red flesh, with white connective tissue between them. Boiling the meat dissolves this connective tissue to a certain extent, so that the bundles of fibers more readily fall apart.

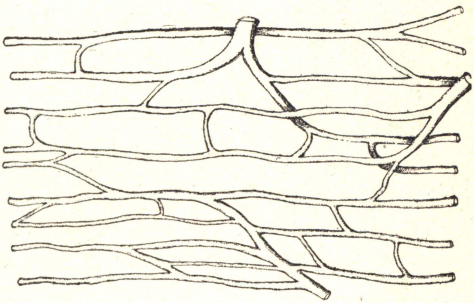


FIG. 62. — The capillary blood vessels of muscle, magnified. The drawing is made from the same specimen as Fig. 60, only the muscular fibers are not shown.

Structure of Involuntary Muscle. — Involuntary muscle is quite simple in its structure. It consists of a number of spindle-shaped cells, held together by a cement. This cement substance is found throughout the body. It is of the nature of glue, or cement, and it firmly holds many of the cells of the body together. Fig. 63 represents

some involuntary muscle which has been treated with dilute acid. The acid has dissolved the cement, and the cells are seen well separated from each other. These cells are very minute, and a high power of the microscope is required to see them.

FIG. 63. — The cells of involuntary muscle, magnified.

The Tendons. — The voluntary muscles are sometimes attached directly to the skin and to other soft tissues; but the great majority are connected to the bones by firm, white cords. These white, shining cords are called **tendons.** The tendons have no power of themselves to contract. They simply serve the purpose of cords, connecting the working part of the muscle with the part which it has to move. The parts acted upon may be situated a considerable distance from the controlling muscle; thus, the ends of the fingers are moved by the muscles of the forearm.

The tendons serve another purpose: owing to their compact nature they occupy much less room than do the muscles, thus the small size of the wrist and ankle is made possible. Were it not for this fact, these joints would be covered with thick muscle, and it would be quite impossible to have the necessary freedom of motion. The tendons at the wrist can be easily felt, while the one attached to the thumb is easily seen on the back of the hand. The largest tendon in the body, shown in Fig. 57, is called the *tendo Achillis.* According to the Greek legend it was at this point that Achilles received

his death wound, as there was no other portion of his body that could be wounded.

Fig. 64 illustrates the muscles of the forearm and their tendons. The tendons are held tightly down at the wrist by firm bands of tissue. Some of the tendons extend to the very ends of the fingers, so that when the muscles of the forearm contract, they move the most distant parts of the hand. The tendons are inclosed in sheaths, through which they easily glide.

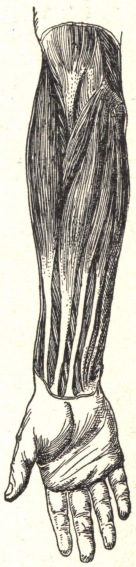


FIG. 64. — The muscles of the arm, ending in the white tendons at the wrist.

Muscular Contraction. — By placing the fingers of one hand upon the fleshy part of the other hand, at the base (or ball) of the thumb, the tissue will feel soft and comparatively thin. This tissue consists of voluntary muscle, and can be made to contract by an effort of the will. With the fingers still in the position indicated, place the thumb on the end of the little finger; the muscle now feels thick and hard. From this we conclude that when a muscle contracts, it becomes thicker and harder. We know that a muscle shortens when it contracts, because it moves the parts to which it is attached.

A study of Figs. 66, 67, 68, 69 will illustrate the principle upon which all voluntary muscles act. If the muscles on the front of the arm should shorten, the hand would be raised; while if the opposing muscles on the back of the arm should shorten, the hand would be drawn down again. If the muscles on the

front of the leg should shorten, the toes would be raised; while the opposing muscles would raise the heel. Thus we

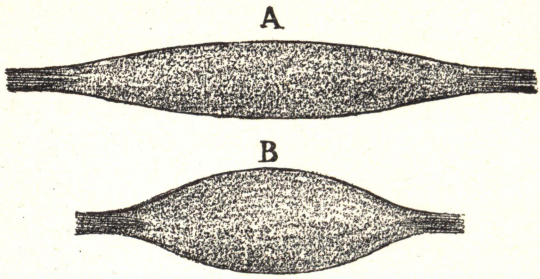


FIG. 65. — A, a muscle relaxed, before it contracts; B, the same muscle contracted; it is shorter and thicker.

learn that when a muscle contracts, it becomes thicker, harder, and shorter; and that all the movements of the body are caused by such contractions (Fig. 65).

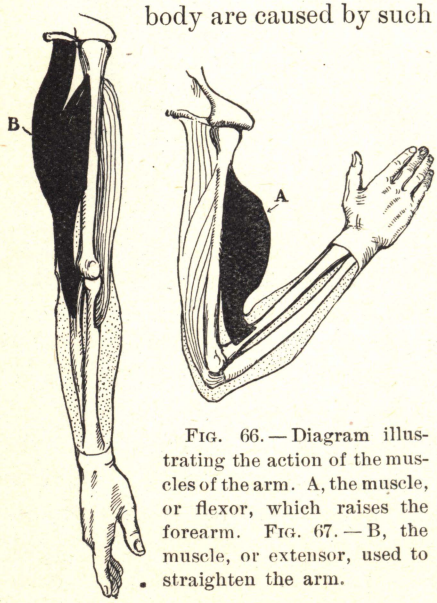


FIG. 66. — Diagram illustrating the action of the muscles of the arm. A, the muscle, or flexor, which raises the forearm. FIG. 67. — B, the muscle, or extensor, used to straighten the arm.

In the case of the involuntary muscles, the individual spindle-shaped cells contract. If the cells be arranged in a circular manner, as around the arteries, then their contraction will diminish the size of the vessel. For the same reason, if the muscular cells that form the walls of the stomach contract, they will diminish the size of the cavity, and will force out its contents.

But a muscle cannot remain in a state of contraction for any great length of time. It soon tires and is obliged to relax. After a short rest, however, it is again ready for work. All muscles must have rest, or they will soon wear out.

The Use of Levers in the Body. — Have you ever watched workmen moving heavy stones or timbers for a new building? You might often see them take a pole, put one end on the ground under the timber to be moved, lift up on the pole, and let the timber slide along. Sometimes, instead of lifting up on the pole placed under the timber, they would put a small block below the pole, close to where it goes under the timber, and then raise the timber by pressing down on the pole. These are two forms of what we call "prying." An engineer would use somewhat different terms. He would tell you that the pole was a lever, the ground or the block on which the pole rested was the fulcrum, and the object to be moved was the weight. We apply the same principle whenever we move our bodies; without some form of "prying" we could not sit or stand or walk or lift.

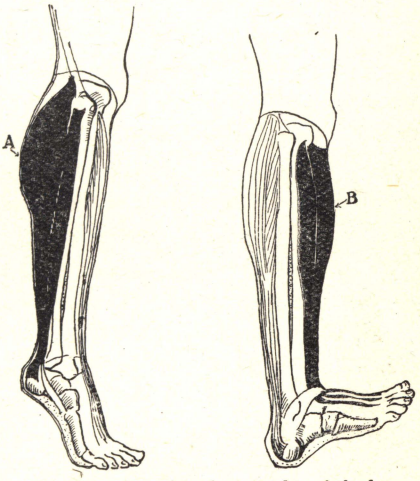


FIG. 68. — Showing the muscles of the lower leg contracted at A to raise the heel. FIG. 69. — The contraction of the opposing muscles to raise the toes.

Try a few experiments in prying. Take a book and

pry it along the desk with a ruler, or lift it with the ruler by placing a pencil under the ruler near the book. Then lay the ruler on the floor, place a foot on one end and a book on the other; grasp the ruler near the book and lift up. The book is raised as readily as before. Then slip the fingers along the ruler close to the foot and lift. You will have to lift hard to raise the book in this position; this last experiment illustrates what you do unconsciously every time you lift your hand. If you place a book on the palm of your hand and raise it slowly, the book is the weight, the forearm is the lever (corresponding to the ruler), your elbow is the fulcrum, serving as your foot did in the other experiment, and the big muscle on the front of the arm is the power applied to raise the weight. Owing to the short space between the elbow (the fulcrum), and the power (the muscle), and to the long space between the power (the muscle) and the weight on the hand, the muscle has to exert a large amount of force to move the weight. In other movements of the body we use different forms of this lever principle, and it would be interesting to trace them out. From the hint that has been given you will appreciate why muscles cannot continue violent exercise without some rest.

Harmony in Muscular Action. — The muscles which bend, or flex, the joints are called the **flexors**; while those which bring the bent parts back again are called the **extensors**. Examples of the former are those muscles on the front of the arm which raise the hand; while examples of the latter are those on the back of the arm which pull the hand down again.

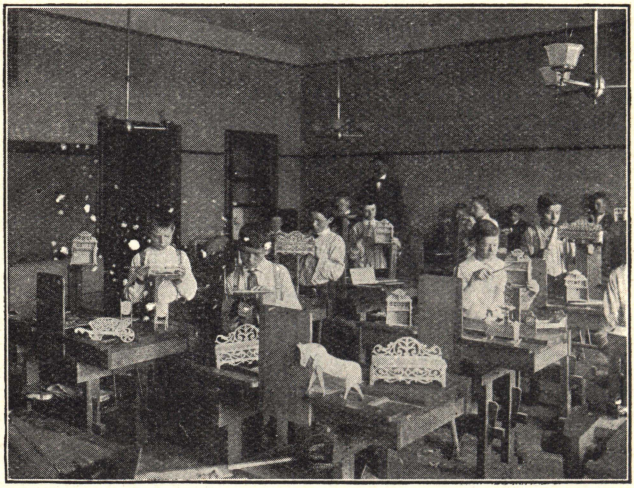
From this description, it is evident that opposing muscles must not act at the same time; for if the flexors and extensors should equally contract, and pull upon the parts

to which they are attached, there would be no motion whatever. To give free motion to a part, the opposing muscles must be finely adjusted to each other. In cases of spasms, or convulsions, the muscles do not act in harmony, and the body becomes stiff and rigid.

The delicacy of the adjustment of muscular action is well illustrated in the muscles of the face. Often the expressions of the face tell more than do uttered words. An unconscious contraction of a muscle, be it ever so slight, may betray, to the close observer, pain or pleasure. A slight contraction of a muscle lifts the brow, and a smile covers the face; while a change in another muscle is followed with an expression of suffering and pain. The infinite variety of tones that can be produced by the human voice is due to the position and tension of the vocal cords, and these are controlled by muscular action.

The Control of the Muscles. — All the muscles are under the control of the **nervous system**. The nerves serve as a connecting medium between the brain and the spinal cord, and the distant muscles. The nerve force is sent from the brain, or spinal cord, down the nerve fibers to the distant muscles stimulating them to contract. If this connection be broken, there will be no muscular action. Training the muscles therefore means training the nerves and the brain as well. When we learn to use the muscles of the hands skillfully, as we must to do good carpentry or good metal work, we have accomplished two different things, — the muscles have been taught to act with delicacy and precision, and the nervous system (brain, spinal cord, and nerves) has been taught to give its orders to the muscles that are involved more accurately and more specifically than it could do without this training. Hence the advantage of the different forms of manual training

that are introduced into school work. These are important not only to the pupil who expects to earn his living by some form of skilled labor, but also to the pupil who



expects later to take up some profession, and may therefore never have another opportunity to get the mental discipline that comes from rightly directed manual labor.

Effects of Alcohol on Muscular Work. — Professor Cushney, University of Michigan, says: "Over and over it has been demonstrated beyond question that regiments supplied with alcoholic liquors are less capable of long marches and suffer more from fatigue than others to which no alcohol is issued."

Dr. E. Destree, late professor in the University of Brussels, said: "Nothing whatever in physiological chemistry authorizes us to admit that alcohol has a favorable influence on muscular work. Bunge asserts that the effects felt are only a symptom of brain paralysis, a benumbing of all feeling of weariness."

Dr. Graham Lusk, Professor of Physiology in University

and Bellevue Hospital Medical College, writes: "It seems hardly necessary to refer to the fact that the use of alcohol in armies, as a means of obtaining additional expenditure of physical force, has long since been abandoned. After taking alcohol, the sum total of work done will not be increased, but rather diminished. The depressant effect is the predominating factor in the long run."

Sir Victor Horsley, M.D., a celebrated brain specialist of England, states: "The disadvantageous effect of alcohol on persons performing muscular work is well known, and it has been proved from the records of military expeditions that the best physical results are obtained under total abstinence from alcohol. The evidence is overwhelming that alcohol in small amounts has a most deleterious effect on voluntary muscular work."

The Most Important Muscles. — Nearly all the muscles have very difficult names of Latin origin, which refer to their location or to the work they have to do. To illustrate: The *occipito-frontalis* muscle is the one that extends from the occipital bone to the frontal bone. When this muscle contracts, it raises the eyebrows and draws the scalp forward. It gives to the face the expression of surprise; and when the contraction is more marked, the expression of fright or horror.

An illustration of a muscle named by the nature of its work is the *masseter* muscle, the name being derived from a Latin word, meaning "chewing." Hence the muscles on each side of the face are called the "chewing muscles." By placing the fingers over the angle of the lower jaw, just over the lower molar teeth, and pressing the teeth firmly together as in chewing, the muscle will be felt to thicken and harden as it contracts.

Other important muscles are as follows: The *buccinator* muscle is between the upper and lower jaws at the sides of the face. During mastication these muscles contract holding the cheeks firm so that the food is kept between the teeth. When the cheeks are distended with air, the buccinators contract and dispel it from between the lips. This name is given to the muscle because it is used so largely in blowing glass and in blowing wind instruments. It is named from the Latin word meaning "trumpet."

The *tongue* is a large voluntary muscle capable of a variety of movements.

The broad flat muscle that covers all of the upper and back part of the neck and shoulders is called the *trapezius*.

On the upper and front part of the chest is a large muscle, the *pectoralis major*, or large muscle of the chest. It aids in drawing the arm inward and forward, and is often very largely developed in strong men.

The *diaphragm* is a thin muscle that completely divides the thoracic from the abdominal cavity. It is attached to the ribs and to the *spine*. By its contraction it takes a very prominent part in respiration. The *intercostal* muscles are between the ribs. By contracting they raise the ribs and thereby increase the capacity of the chest. They are very important to respiration, aiding in the work of the diaphragm.

The large thick muscle which completely covers the shoulder is the *deltoid*. The *biceps* covers the whole of the front of the upper arm. It is the great flexor muscle of the forearm. It is this muscle that is largely used in climbing or in drawing the body up when hanging by the hands to a limb or pole. Its swelling and hardening may be easily felt by placing the left hand over the front of the right arm and then raising the right forearm forcibly, as if lifting a heavy weight. This muscle is largely developed in athletes, and in all who are engaged in heavy manual labor.

The *triceps* is the great extensor of the arm, covering its entire back surface; it is the direct antagonist of the biceps. There could be no bending of the forearm if both these muscles should act at the same time.

The muscles of the thigh are very large and strong, many of them extend from the hip to the knee. The greater part of the calf of the leg is formed by a strong, large muscle called the *gastrocnemius*. It terminates below in a tendon called the *tendo Achilles*. This muscle, with smaller ones by its side, is constantly brought into use in walking, standing, leaping, etc. It draws the heel up and thus raises the whole body from the ground; while the body is thus supported the other leg is carried forward.

PLATE VI

The location and action of some of the more important muscles: (1) the biceps, contracted, bending the arm; (2) flexor muscles of the forearm, contracted, pulling the tendons of the wrist, thereby bending the fingers; (3) pectoralis major, the chest muscle, draws the arm across the front of the chest; (4) the deltoid, covers the shoulder, carries the arm outward and upward; (5) the triceps, contracted, extending the arm; (6) extensor muscles of the forearm, contracted, pulling on the tendons, (7) (8), extending the thumb and first finger; (9) muscles about the hips; (10) flexor muscles of the thigh, contracted, bending the leg; (11) gastrocnemius muscle, contracted, pulling on the tendo Achillis (12), and slightly raising the heel. The whole weight of the body is on the right leg, hence all of these large muscles are tense and firm.

CHAPTER XVII

EXERCISE

Exercise Necessary. — Exercise of the muscles is absolutely necessary to keep them healthy and strong.

But no one admires a man who has strong muscles, and a sluggish brain; so we conclude that it is unwise to develop one particular part of the body and to neglect some other portion. The endeavor should be to develop all parts equally well. A proper amount of exercise is one of the essential conditions for perfect bodily development.

Many a young and enthusiastic pupil has been so carried away with his desire to excel in his studies, that every hour spent in other labor, or in rest, was regarded as so much time wasted. He failed to remember that the sound mind must be in a sound body to bring forth its highest and best results. It is of vital importance that at least one or two hours of each day be spent in outdoor exercise. No matter how cold the air may be outside, no one need fear taking cold if the body be kept in active exercise, and if rest be taken in the warm house. Outdoor exercise is always to be preferred to that taken indoors, because outdoor air is the purest.

Work and Rest. — Each time a muscle contracts, there is a waste of some of its substance. During the active work of a muscle, the waste far exceeds the repair. The worn-out material accumulates faster than it can be carried away, and the body experiences a sense of fatigue.

If exercise be continued until the body is greatly fatigued, and if such exercise be frequently repeated, the muscles will gradually waste away, just as they would if they were not used at all.

If a muscle is made to work, it must have its periods of rest. The heart never appears to be tired. It beats on year after year, with an astonishing regularity. But it would soon wear out, did it not have a period of complete rest between its beats. In order that the muscles

A Class taking Gymnastics Out of Doors.

may be kept in a healthy condition, there should be proper exercise followed by repose.

The Amount of Exercise. — If exercise is so important for the general health, what is to be considered a proper amount? This varies within wide limits, according to the health and habits of the individual. If the organs and tissues of the body are poorly nourished, so that even slight exercise gives great fatigue, then the exercise should be very short, and followed by long rest. But the fatigue following exercise felt by those in delicate health will grow less and less if the exercise be steadily continued; always remembering to rest as soon as one begins to feel

tired. On the other hand, a healthy person may exercise until all the muscles are thoroughly tired, and yet, after a night of sound sleep, awake feeling all the better for the work.

It is safe to say that general exercise should not be too violent; overexercise is nearly as bad as no exercise. Any exercise is too violent which leaves the body exhausted. Such exercise unfits the body for regular work and may prove injurious to the nervous system. Healthful exercise should bring a restful feeling, a desire for work, and refreshing sleep.

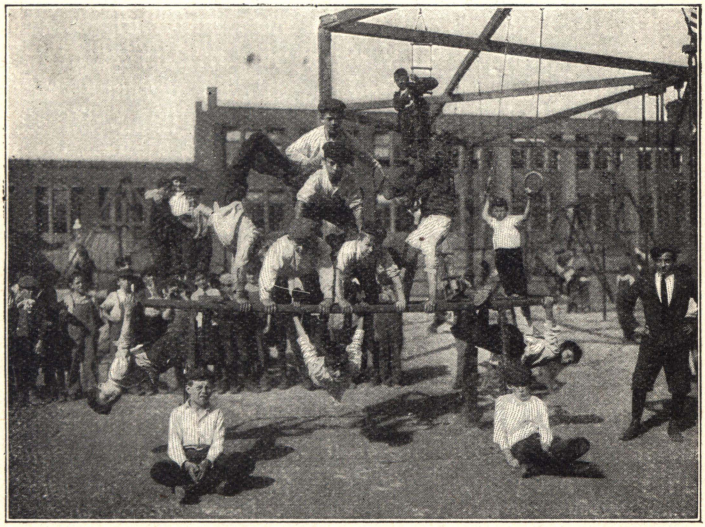
Walking. — The gentlest form of active exercise is walking. It throws into action nearly all the larger muscles of the body, except those of the arms. The advantage of this form of exercise over gymnastics is that it takes the person out of doors. Here the varied scenery has its exhilarating effect on the nervous system, and purer air is inhaled. To derive the full benefit of walking, it should be undertaken with a feeling of freedom and pleasure.

The Bicycle. — One advantage in using the bicycle is that the mind is refreshed by the changing scenery and the whole body is brought into active service. It is a convenient and economical conveyance, and its proper use forms one of the most valuable exercises. But the rider should sit in a correct position, and not bend low down over the forward wheel. He should be careful also not to overexert himself climbing hills.

Other Forms of Exercise. — Rowing is a very healthful exercise, and tends to develop many parts of the body. It is likely to prove injurious when long continued at a time, and when the muscles are used too violently. Horseback riding is an excellent exercise. It brings into play nearly

all the muscles, while the fresh air and changing scenery impart a healthy tone to the entire nervous system. Tennis, golf, baseball, football, sliding, skating, — all these are pleasant and beneficial forms of exercise.

How to find plenty of exercise in the open air does not trouble the farmer's boy, who has to get up early in the morning, do his part of the chores, and then walk a long



AN OUTDOOR GYMNASIUM, — A CITY SUBSTITUTE FOR COUNTRY SPORTS.

way to school. But he is the boy who eats heartily, sleeps well, and is not easily fatigued. He is laying the sure foundation for a healthy body.

Benefits of Exercise. — The muscles are not the only parts benefited by exercise; the general health of the entire body is greatly promoted. Were this not true, but little would be said about muscular exercise; for simply to become physically strong should not be our highest

ambition. The mind of man is more to be admired than his muscular strength. It is because a healthy body is such a great aid to a vigorous mind that an abundance of exercise is so persistently urged.

A proper amount of exercise increases the healthy action of the heart, and makes the blood flow more freely through

OUTDOOR GYMNASTICS IN A VACATION SCHOOL.

the organs and tissues. It brings more air into the lungs, increases the appetite, and aids digestion. From this it logically follows that bodily exercise tends to give more activity to the mind and to strengthen the mental powers.

Effects of Alcoholic Drinks on Muscular Action. — The value of muscular action depends upon the contracting power of the muscle, the exactness of its control by the

brain, and upon its power of endurance, that is, the length of time the muscle can sustain a given amount of work. As the limit of endurance approaches, the feeling of fatigue comes on and increases until rest becomes necessary.

The man who earns his living by muscular labor naturally wishes to have strength of muscle and to have it hold out until his task is accomplished. But if he takes a drink of beer or ale, or some other alcoholic liquor, when he begins to feel tired, he reduces his working ability for the rest of the day. He may think for a little while that he feels better, because the alcohol dulls his nerves and makes him less conscious of his weariness, but he quickly becomes more tired than he was before.

He may think too that he can do more and better work while the effect of the alcohol lasts, but here again he is mistaken, as careful tests will show. The difference in the quantity and quality of his work can be clearly seen by careful comparison made by another person whose brain is unclouded by alcohol. The reason the drinker himself is deluded is because the alcohol that dulled his brain until he no longer felt tired, dulled his judgment also. At the same time, the poisoned brain could not so well control the movements of the muscles and a portion of the energy he expended was misdirected. This is a particularly serious matter to the men engaged in industries that require exact and skillful work.

Efficiency requires strict attention to the matter in hand, and the ability to hold in check an impulse to move until the mind decides just how the motion should be made in order to be right. One of the first effects of alcohol is to lessen the power of self-control and to increase the tendency to muscular movement; hence in proportion to the amount he drinks it robs the skilled workman of his skill. For the

same reason, the man who drinks is out of place in any employment that involves responsibility for life and property. Railroad superintendents and other managers of large and important industries have learned from experience what men of science have verified by laboratory experiments; namely, that alcohol diminishes working ability. The individual, the business concern, or the nation that would strive for the front rank in the world's work must cut loose the shackles imposed by alcoholic drinks.

At one time Mr. Carnegie added ten per cent to the wages of his abstaining workmen. When inquired of as to the reason for this action, he wrote: —

"Men are not required to be total abstainers, but all who are can obtain from me a gift equal to ten per cent of their wages, with my best wishes, upon stating that they have abstained for a year. I consider total abstainers worth ten per cent more than others, especially if coachmen, yachtsmen, or men in charge of machinery."

Professor Adolf Fick, of the University of Wurzburg, said: "Every penny which the workman spends for alcoholic drinks is not only wasted but employed for a destructive purpose. The workman would use the money expended for alcohol to best advantage if he purchased fatty foods and sugar in its stead."

Effects of Tobacco on Working Ability. — Dr. J. W. Seaver, Supervisor of Physical Training at Yale University, has made some interesting studies of the effect of tobacco upon muscular exertion. He says: —

"Whenever it is desired to secure the highest possible working ability of the organisms, as in athletic contests where the maximum effort is demanded, all motor depressant influences are removed as far as possible, tobacco being one of the first substances forbidden. . . . Experiments carried out by Dr. W. P. Lombard, of the University of Michigan, have shown that even moderate amounts of tobacco in the form of smoke lower the working power of the human muscle by a high percentage. . . . In from five to ten minutes after beginning to smoke an ordinary cigar, muscular power began to diminish, and in an hour, when the cigar was burnt, it had fallen to about twenty-five per cent of its initial value. The total work of the time of depression, compared with a similar normal period, was 24.2 to 44.8."

CHAPTER XVIII

THE SKIN

General Description. — The skin forms a strong, close-fitting garment for the body, protecting the delicate and sensitive parts beneath. In the case of a medium-sized man the skin is equal to sixteen square feet of surface. It is not fastened tightly to the tissues; but is held by delicate bands of connective tissue (Fig. 70), which are of a loose or open nature. This allows the skin to be raised and gathered in folds, and also permits free movements of the skin over the joints and muscles. In some parts of the body, as the soles of the feet and the palms of the hands, it acts as an elastic pad. It affords protection from external injuries of a mechanical nature, and also from the action of chemicals or poisonous substances. It binds all the outer parts of the body together, giving it symmetry of outline. It has much to do with regulating the temperature of the body.

FIG. 70. — Cells from connective tissue, magnified.

The skin is also a great excretory organ, actively concerned in the removal from the body of substances that would prove injurious, if allowed to remain.

Adipose Tissue. — The connective tissue beneath the skin usually contains more or less **adipose**, or fatty tissue, Fig. 71. In thin persons there may be very little fat, and the outlines of the tendons and muscles, and even the shape of the bones, may show through the skin. In fleshy persons the fat may be in great abundance, pushing out the skin, and causing the wrinkles and outlines of the parts beneath to disappear. In the average healthy body there is always some fat in the tissues beneath the skin. In old age the fat is likely to disappear, causing the skin to form in folds or wrinkles. The fatty tissue is of use as an aid in retaining the heat of the body, thus taking the place of so much extra clothing.

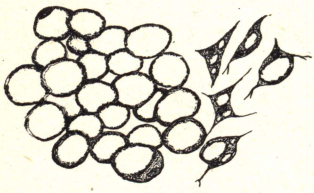


FIG. 71. — Fat cells, magnified; to the right are five connective tissue cells partly filled with fat.

The Two Layers of the Skin. — The skin is composed of two layers, the **epidermis** and the **dermis.** The epidermis, which is also called the **cuticle**, or false skin, forms the outer layer. It is composed entirely of cells, Fig. 72. The outer ones are very hard and dry and are being constantly removed. The epidermis has neither blood vessels nor nerves; it is, therefore, bloodless and without feeling. For these reasons it is possible to remove nearly all the epidermis by gently scraping the skin with a knife without causing pain or the

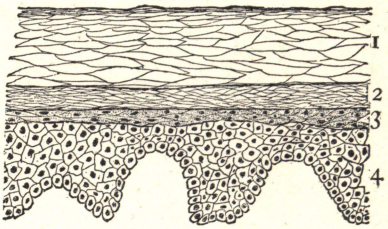


FIG. 72. — A cross section of the epidermis, magnified: (1) the layer of cells nearest the surface of the body; (2, 3, 4) other layers of cells.

flow of blood. But as soon as the true skin, the **dermis**, is reached, the scraping causes pain and the blood begins to flow.

In a blister the epidermis is entirely separated from the dermis. An ordinary blister on the hand shows a thin membrane, raised from the parts beneath, and separated

FIG. 73. — A section of the human skin, magnified: (1) the epidermis; (2) the duct of a sweat gland; (3) a sweat gland: (4) the ending of a nerve, for the sense of touch; (5) coils of minute blood vessels; (6) a hair follicle, in which is a hair; (7) a muscle, which can move the hair follicle.

from them by a watery fluid. Such a membrane may be cut without giving pain or starting blood; for it is the epidermis of the skin. After the thin membrane is removed, if the red surface beneath it be touched, it will be found highly sensitive and is easily made to bleed.

Epidermis rapidly Changing. — The epidermis is a good illustration of the wear and waste of the body. The outer cells are constantly falling off in vast numbers; immense numbers are removed daily by the friction of the clothing, and by the work of the sponge and towel at the bath. This loss is being steadily made up by the formation of new cells in the deeper parts; these come to the surface as the ones over them disappear.

If all of the epidermis were removed at once, the parts left would be very red and tender; but in the case of the blister, a few cells of the epidermis are left clinging to the true skin; these rapidly multiply until within a few days a complete new epidermis is formed. After some fevers, as during the "peeling" of scarlet fever, large masses of cells are removed together.

Uses of the Epidermis. — The outer layer of the epidermis, as seen at (1), Fig. 72, consists of closely packed, hard cells which make a very complete and almost impenetrable covering. Therefore, the epidermis is a protection against the absorption of poisons.

The surgeon is not harmed while operating on diseased portions of the body, because the epidermis prevents the absorption of any poisonous matter; but there are many cases on record where the skin on the surgeon's hand was accidentally cut or broken while operating, thus allowing diseased matter to be absorbed, producing blood poisoning and even death. Immersing the whole hand in poisonous matter might possibly do no harm, provided the epidermis were in a perfect condition everywhere; but a prick might cause death. The epidermis also protects the parts beneath from the sudden changes of heat and cold.

The Coloring of the Skin. — The **color of the skin** depends largely upon the character of the deepest cells of

the epidermis, as at (4), Fig. 72. In very light skins, these cells are colorless; in darker skins, the cells have a slight amount of dark coloring matter in them; while in the darkest skins, the coloring matter is very abundant. The destruction of these deep cells causes the epidermis to appear perfectly white, as it does in certain diseases. The white skin of the Albinos is due to the absence of any coloring matter in these cells. A free supply of blood to the skin gives it a red or pink color; while any interference with the action of the liver may give a jaundiced or yellow color to the skin.

The Tactile Bodies. — The **tactile bodies** give the sense of touch. They are situated in the dermis, or true skin; they reach to the epidermis, but do not penetrate it. Wherever the sense of touch is the most delicate, there are found the largest number of tactile bodies. Over one hundred of these bodies have been counted in a space $\frac{1}{50}$ of an inch square. They are very small, averaging no larger than $\frac{1}{350}$ of an inch in length. Thus the microscope shows that while it is true that the epidermis has neither blood vessels nor nerves, yet just beneath it are nerves, illustrated at (4), Fig. 73, especially arranged for the sense of touch. The dermis is also well supplied with blood vessels.

The Sweat Glands. — The **sweat glands** are found in the deep parts of the dermis, or in the tissue immediately beneath the dermis. In Fig. 73 these glands are represented as minute tubes arranged in circular coils. That part of the tube which is not coiled, but which extends from the gland to the surface of the skin, is called the **duct**: the duct pursues a spiral course, as represented in the figure, and opens on the surface with a funnel-shaped enlargement.

If the ridges which appear so plainly on the ends of the fingers and palms of the hands be examined with a small magnifying glass, it is possible to see the minute depressions in the center of them; these represent the openings of the sweat glands. The view obtained will resemble that given in Fig. 74. The openings are quite close together, in some places averaging as many as three thousand to the square inch. From the surface of the skin to the coiled glands is about one fourth of an inch. It is estimated that there are over three millions of these glands in the entire skin.

The Perspiration. — The **perspiration** is a colorless fluid secreted in the coils of the sweat glands. It is of very simple composition, over 99.5 per cent of it being water. Some inorganic substances, as sodium chloride (common salt), give it a salty taste; while some organic substances impart to it an odor. The perspiration is a continuous secretion. When it is small in amount, the water is evaporated from the skin at once, therefore its presence on the skin is not noticed; this is called the **insensible perspiration**. As soon as the secretion is increased, it does not all evaporate, but gathers as drops of sweat on the surface; this is called the **sensible perspiration**. Many conditions cause the amount of perspiration to vary. In some individuals the whole amount per day is very small; while in

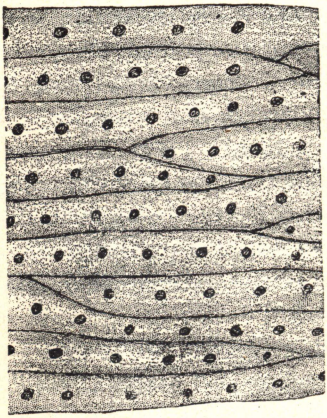


FIG. 74. — The surface of the skin, slightly magnified, showing the openings of the sweat glands.

others it is very large. It is a fair average for the year through to say that about two pounds are secreted each day.

There is a marked difference in the perspiration of the lower animals ; the horse perspires freely ; the ox to a slight extent only ; and the dog but little, if any. The panting of the dog after exercising allows much water to be given off from the tongue and from the body through the lungs; and in this way the object of regulating the temperature of the body is gained, as will be described later.

Conditions affecting Perspiration. — An increase in the temperature of the surrounding air will cause an increased secretion of the perspiration. Individuals who work in furnaces, or in places of very high temperature, often perspire as much in an hour as the average person will in a day. Those who perspire freely ought to drink a large amount of water to supply the loss, or the system will soon become exhausted. An extra amount of water in the system will increase the secretion. Muscular activity is well known to do the same. Certain drugs excite very copious perspiration, while other drugs diminish it. The secretion is lessened by cold ; in fact, it may be suddenly arrested by this means. Any departure from health also may cause it to vary, ranging from the hot dry skin of fever to the profuse night sweats of consumption.

There is a direct relation existing between the action of the kidneys and the skin. In summer, when the skin is active, the secretion of the kidneys is much lessened ; while in winter, when the skin is less active, the work of the kidneys is increased.

Object of the Perspiration. — The chief object of the perspiration is to regulate the temperature of the body. It is well known that when a liquid evaporates, it produces cold. So the evaporation of a number of pounds

of water each day from the surface of the body during the warm days of summer causes a considerable lowering of the temperature. Exercise during the summer would be quite impossible were it not for this fact. The exercise causes rapid oxidation in the tissues, and this produces heat; and added to this is the heated atmosphere. Were not some way provided of cooling the body, it would soon be in a raging fever. But the more one exercises and the higher the thermometer, so much more profuse is the perspiration, while its rapid evaporation causes the body to remain at about a fixed degree of heat.

Checking the Perspiration. — Sudden cooling of the skin checks its action, throws additional work on other parts of the body, and often causes disease. One of the most frequent causes of a cold is the sudden checking of the perspiration. After exercising, or whenever the body is perspiring freely, great care should be taken in regard to draughts of air. The body should be gradually cooled, with some extra clothing thrown over the shoulders, while resting. Sudden checking of the perspiration is positively injurious and may easily lead to fatal results.

Ordinary Diseases of the Skin. — The more ordinary diseases of the skin are the hives, heat rash, eczema, acne, and the itch.

The **hives**, or nettle rash, is often caused by some disturbance of the digestion. The skin becomes very red, and there is great burning and itching. Sometimes the eruption is in small spots distributed over the body, or it may take the form of an even rash over a portion of the body. Some persons cannot eat clams, lobsters, oysters, or any kind of fish, without having an eruption of the skin. Others cannot eat strawberries without bringing on such an eruption. Usually this is a very simple

disease and passes away as soon as the cause is removed. A gentle laxative, such as a seidlitz powder, is generally all the treatment that is necessary.

Heat rash, or prickly heat, is an affection of the sweat glands of the skin. It is generally caused by exposure to extreme heat, by working in an overheated room, or from wearing too heavy clothing in hot weather. This is not a serious disease, and, when the cause is removed, it does not ordinarily require treatment.

Eczema is more familiarly known as tetter, or salt rheum. At first there is only a small red spot, or a number of these spots arranged in clusters. The skin itches and burns, and soon scales are formed over the inflamed places ; there may be a large surface inflamed in this way. The disease has a tendency to become chronic unless promptly treated, therefore a physician should always be consulted with reference to it.

Scabies, or the itch, is a highly contagious disease. It is caused by the presence of minute animals that have penetrated just beneath the surface of the skin. By their presence they produce an irritation which causes most intense itching, especially between the fingers. The disease may extend all over the body, and the itching may become severe enough, when the body is warm in bed, to prevent sleep and to cause great discomfort. This disease may be completely cured, but the services of a physician are necessary.

Acne is another disease of the skin which is very common among young people. It consists of minute pimples, in the center of which there is usually a little yellowish matter. Acne is generally due to some disturbance of the digestive system, hence in order to make the cure complete careful attention should be paid to the

diet, and to all the general rules of health. Each pimple should have its contents removed by pressing it carefully with the fingers, which have first been carefully cleansed, or with some blunt instrument. When there are blackheads it is quite necessary that these be removed if the cure is to be prompt and permanent. The best local treatment for a face in this condition is to wash it with very hot water for five or ten minutes, morning and night. Cold water should be next applied, and then the face should be thoroughly dried with a soft towel. During cold weather it may be best to use the hot water only at night.

Shingles is a disease which consists of a rash, extending in a circular manner halfway around the waist. The skin burns and smarts, and the general system is often more or less affected. It is a disease that requires the services of a physician.

There are diseases caused by very low forms of vegetable life, called **ringworm**, **scald head**, and **barber's itch**. These vegetable growths can be seen with only the very high powers of the microscope. All these diseases are very contagious, and should be promptly treated by a competent physician.

The Hair. — A **hair** consists of the **root** and the **shaft**. The former is situated in the skin, and the latter projects from it. The hair may be easily removed from its **sac** or **follicle**, without damage. At the lower end of each hair follicle is a small eminence, or **papilla**, which is well supplied with blood vessels. The root of the hair rests on this papilla and grows from it. The cells of the papilla multiply and grow, pushing those already formed upward toward the surface. A hair, therefore, grows entirely from the root, from this minute papilla. If a hair is removed, another begins to grow at once from the papilla,

and in time will appear on the surface. Only a destruction of the papilla can prevent the hair from growing.

The hair shaft is not hollow, although its center is composed of cells more loosely arranged than those forming the exterior. Hair is very elastic; with proper care it can be made to stretch nearly one third its entire length before breaking. It is also very strong, — a single hair being capable of suspending a body weighing from three to five ounces.

A glance at Figs. 75 and 76 shows that the microscope reveals a great difference between the hairs of the lower animals and those of man. In certain cases the difference is very marked, as here shown, while in others it is not so marked.

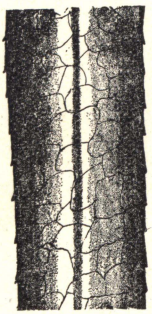


FIG. 75. — A human hair, magnified.

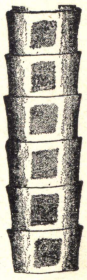


FIG. 76. — A cat hair, magnified.

Muscle of the Hair. — In Fig. 73 it is noticed that the hair is placed obliquely in the skin. Fastened to the lower part of each hair sac, and extending obliquely upward and to the left, is a minute bundle of involuntary muscle. This muscle is better shown at M, in Fig. 77. The muscle is thus arranged at an acute angle, so that when it contracts, it pulls on the base of the hair sac, causing it to stand more nearly erect. In this way the hair is made literally "to stand on end." A contraction of this muscle produces the condition known as "goose skin."

The Sebaceous Glands. — The **sebaceous** or **oil glands** are situated by the side of the hair sacs, into which they open by a duct, as illustrated in Fig. 77 at G. These

glands secrete an oily substance which is spread around the hair, making it smooth and glossy. Some of the secretion extends over the skin, making it soft. Often the ducts to these glands become stopped up, and the secretion distends the glands, forming "black heads."

Care of the Hair. — In the case of boys, the head should be washed once a week with soapy water, and then thoroughly rinsed with clear water. Then rub the head thoroughly with a towel until the head and the hair are both perfectly dry; if this is done, there need be no fear of taking cold. As girls have hair that is longer and heavier, it cannot be dried so easily; hence they cannot well wash the scalp so frequently.

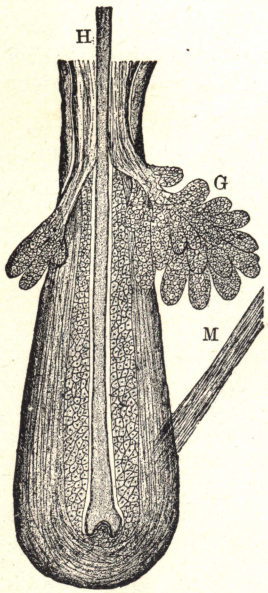


FIG. 77. — A human hair in its sheath, or follicle, magnified: H, the hair shaft; M, the muscle; G, the oil gland.

The Nails. — The nails grow from behind forward, thus being constantly pushed outward. They protect the ends of the fingers and toes, and give aid to the fingers in picking up small objects. If a nail be removed, a new one will take its place in a few weeks, provided the root is not injured.

Care of the Hands. — Great care should be used that the hands are kept as clean and neat as possible at all times. This refers also to the nails. The finger nails should be kept neatly trimmed, and should always be perfectly clean. Biting the nails injures their shape and is disagreeable to the witnesses.

CHAPTER XIX

BATHING — CLOTHING

Necessity of Bathing. — We know that an immense number of sweat glands are constantly pouring their secretion on the surface of the skin ; that vast numbers of oil glands are depositing an oily substance on the surface also ; and that the cells of the epidermis are constantly loosening and falling off in great numbers. It is only necessary to recall these facts, in order to understand fully the necessity of frequent bathing. The glands of the skin have a certain work to do ; how can they properly perform this if their ducts be closed by an accumulation of such material on the surface ? If these glands cannot perform their full duty, then other glands or organs must do it for them, or sickness will follow.

Always considered Important. — The nations of antiquity had much to say about the bath, both as a luxury and as a means of preserving the health. The public baths of Rome were among the most interesting of her works of grandeur and beauty. Most beautiful works of art have been recovered from their ruins, all speaking of the splendid preparations made for the bath. The price charged for a bath in these elegant quarters was very low, so that all of the people could enjoy its benefits. After bathing, the skin was usually anointed with perfumed oil, and this was followed by light exercise for a short time. In those days nearly every one could swim ;

and to be unable to swim was about as great a disgrace as to be unable to read.

When to Bathe. — Probably immediately after rising in the morning is the best time to bathe. The body is rested, reaction is easy, and the circulation is at its best. The ideal daily bath is a cold sponge bath taken immediately after rising, followed with a brisk use of the towel. One should never bathe when greatly fatigued, nor use a cold bath if feeling chilly. Neither should a bath be taken immediately before or immediately after a hearty meal. It should not be taken soon after a meal, because the rubbing brings the blood to the surface, and therefore must take some of the blood away from the stomach, where it is needed. Great caution should be used in bathing when the body is overheated, and when it is perspiring freely ; because if the water should be too cool, or if the rubbing should fail to produce a complete reaction, then a severe cold or something more serious might result. Avoid both water that is too cold and water that is too hot.

The Cold Bath a Tonic. — A healthy person should regard the bath as something more than a cleansing process. It should be a tonic of the most invigorating character. The first effect of the cold is to drive the blood from the skin ; but soon reaction takes place, and the blood returns with renewed force, filling the capillaries of the skin, and imparting a healthy glow to the entire surface. Just at this time the bathing should cease. The brisk use of the towel heightens the flow of blood, and the whole body becomes enveloped with a pleasant sense of comfort and warmth. To remain longer in the bath would be to send the blood from the surface for the second time, from which reaction might

not occur, causing a sensation of chilliness and fatigue. The brisk work of the rubbing causes the exercise of many muscles, and the whole body is thereby aroused to activity.

The cold bath is injurious to those who do not have a quick reaction from its use. The skin should be left red and warm, and the whole system ought to be invigorated. If not, and if the opposite be true, then the cold bath is injurious rather than helpful. If the bath be short at first, if the water be cool, if it be continued daily, if the towel be used briskly, and if only a portion of the body be bathed at a time, then it must be of benefit. Soon the water can be used colder and the time of the bath extended. With these precautions in mind, it is safe to assert that there are very few young people, in fair health, who would not be greatly benefited by the daily use of the cold bath. A quick sponge bath with cold water, followed by thorough rubbing, is the best method to illustrate the advantages and safety of the cold bath.

Salt-water Bathing. — Many persons who visit the seashore plunge into the cold water at once, and remain there for a number of minutes. If they have been accustomed to the cold bath at home, there can be no more healthful exercise. The beating of the surf against the skin is an invigorating tonic in itself, while the muscles of the whole body are brought into action in withstanding the force of the waves. The change of scenery and the freedom from care aid in imparting new life to the seaside bather. If he be unaccustomed to the cold bath, however, and suddenly begins to spend from twenty to thirty minutes in the sea, he must expect undesirable effects to follow. A vast amount of sickness is caused in this way, which might be prevented.

Other Forms of Baths. — A Turkish bath is one in which the bather is placed successively in rooms of increased temperature; then rubbed; and, at last, douched with cold water. For a Russian bath, the person is placed in a room in which steam is escaping from a steam pipe; this is followed by brisk friction of the body. In taking a shower bath the water strikes the body in a number of small streams. A bath is cold when the temperature of the water is from 60° to 75° F.; a tepid bath is from 85° to 95°; a warm bath, from 90° to 104°; a hot bath, from 104° to 110°.

It is a great mistake to suppose that one needs to take an alcoholic drink of any kind after bathing, to prevent taking cold. The notion, however, is a prevalent one, especially as regards sea bathing.

A warm bath once or twice a week, with the use of pure soap, is necessary. But a daily warm bath, in the bath tub, lowers the tone of the system and diminishes its power to withstand disease.

How to Bathe. — There is always a temptation to have the bath tub filled with tepid water, and then to remain in it a long time. But this method deprives the bath of its tonic properties. A bath of this description once a week may be desirable, but is most undesirable for daily use. The better method is to use the hands, or mittens made from crash toweling; quickly cover a portion of the body with cool or cold water; rub this portion dry; and thus proceed until the bath is completed. The whole bath should not exceed five minutes.

The Value of the Bath. — The value of the bath will depend largely on the completeness of the reaction following its use. As stated before, the skin should be warm and the whole system refreshed. But if the skin

be cold, and the body feel chilly and fatigued, or if the bath be followed by headache and general lassitude, then the practice should be discontinued, and a physician consulted to discover where the error rests. The bath is of great value to those who are already well and strong; it is to such that its use is so freely recommended. It is of great value in keeping the various organs and tissues of the body in a healthy condition, and it is therefore a good preventive of disease. The aged and the feeble need special advice for their particular cases; and the bath should be used by them under the advice of a physician.

A Good Complexion. — Bathing is essential if one desires a good complexion. The skin must be active and do its part of the work. Frequent bathing of the face with pure water is especially desirable. Little soap is necessary for the face; its use often causes roughness of the skin. Cosmetics almost invariably contain substances which are injurious to the skin.

The Clothing. — One object of the clothing is to prevent too great loss of heat from the body. The surrounding atmosphere is nearly always cooler than the body, therefore there is a tendency for the body to lose heat. The clothing corrects this tendency in a large measure. Food maintains the heat, and the clothing prevents its escape; for this reason it is true that poorly fed persons need more clothing in winter than those who are well fed. Animals require less food, and are able to do more work, if they are kept warm during the cold weather.

Adaptation of Clothing. — Our clothing should be suitable to the season, and to the time of day. To escape the effects of sudden changes of temperature, the garments worn next the skin should be made of a material which is a poor conductor of heat. Any change from thick to

thinner garments should be made in the early part of the day, as the evenings are usually cooler and the body is more fatigued at night. More clothing is necessary during sleep because the temperature of the air is colder than during the day, and the body is inactive. A person who is exposed to the direct rays of the sun, should consider the color of the clothing. White is the best protection; then, in order, gray, yellow, pink, blue, and black.

Sources of Clothing Materials. — Our woolen clothing is made from the **wool** of sheep. In the western part of our own country the sheep growing industry is very large. In Australia, which is a great sheep raising country, a single flock often contains hundreds of thousands of sheep. After the wool is sheared off, it is thoroughly cleansed, then spun into yarn, and then woven into cloth.

Linen is made from flax. Certain parts of the stalk of the flax are removed and prepared in such a way that it is easily spun into thread; afterwards the thread is woven into cloth.

The **cotton** cloth with which we are all so familiar is made from the cotton plant which is grown so largely in our southern states. The cotton is spun into thread, and then woven into cloth, as is the case with linen and wool.

The Choice of Clothing. — Furs are extensively used during the cold weather. It is not wise, however, to wrap furs close around the throat. They make one much more liable to take cold, and they weaken and debilitate the throat. To be sure, in severe storms, or during unusual exposure, they may be so worn, but as a regular practice they should not be wound around the throat.

Next to fur, wool is the most suitable and hygienic material for winter clothing. All woolen garments are poor conductors of heat, and are therefore valuable for

winter use. Garments that have coarse meshes are the best protection against the cold in winter, and the sudden changes in summer. They should be worn next to the skin the entire year.

Some simple precautions in dress would prevent an immense amount of illness. The sudden changes in temperature and exposure to draughts would not so often be followed by colds, chills, sore throats, and lung troubles, if the body were constantly covered by clothing that constituted a non-conducting medium. Cotton is to be preferred to linen for bed clothing. The outer garments can be regulated according to the seasons.

Wet Clothing should be Changed. — Wet feet are the cause of many a sore throat and severe cold ; and for most persons, it is a great risk to allow the feet to remain damp. They should be dried and rubbed thoroughly as soon as possible, in order fully to restore the circulation. If one is caught in a storm and the clothing becomes damp or wet, it should be changed at the first opportunity. Brisk exercise in the meantime will keep the body from becoming chilled.

When a Cold Starts.—When a cold first comes on, all the blood leaves the surface of the body, causing the skin to become cold and inactive. At this early stage, a cold may frequently be broken up. The object is to bring the blood back to the skin as soon as possible. This is best done by taking a cupful of some hot drink, such as hot lemonade, or hot ginger tea, at the same time putting the feet in hot water. Do this just before retiring, and in winter time have the bed warm so that the body may not be chilled.

Tight Lacing. — Tight lacing is very injurious, and produces a figure that is far from being attractive. It interferes with the free action of the chest, and prevents the blood from getting its full supply of oxygen.

CHAPTER XX

ANIMAL HEAT

Sources of Animal Heat. — It has already been stated that the heat of the body is derived from the food, and from the oxygen obtained during respiration. By the union of these oxidation occurs and heat is produced. This shows that there must exist a relation between the amount of oxygen consumed and the amount of heat produced in the body. Another source of heat is from certain physical processes of the body, as the work of the heart, the general circulation, and the active exercise of the body.

The chief source of heat is found in the muscular system. The muscles form a large proportion of the whole frame, and they are very active during many hours of the day. The greater their activity, the more rapidly will the tissue be exhausted, and new tissue take its place. These changes require the oxidation of much food, and thereby much heat is developed. Next to the muscles as heat producers are the secreting glands. Most rapid changes occur in these glands when they are active, all of which produce heat. The liver is the most important gland in producing heat, the changes taking place in the liver cells being very active and continuous. The warmest blood in the body is found just as it leaves the liver, on its way to the heart, being much warmer here than when it enters the liver. But heat is generated in every

organ and tissue in the body, since every activity contributes to an elevation of the temperature.

Temperature of the Body. — The thermometer (see Fig. 78) shows that different parts vary in temperature. In those parts where rapid changes are taking place, and where oxidation is most marked, the temperature is higher than the average for the body. The blood is constantly passing from one tissue to another, carrying warmth from the tissues where heat is being developed to other tissues where it is being lost; thus the blood tends to equalize the temperature of all parts of the body. The temperature is generally ascertained by placing the bulb of a thermometer under the person's tongue. The loss and production of heat are so evenly balanced that the temperature of the healthy adult body varies little from 98½° F. This is maintained with only slight variation throughout life. So accurately is this adjusted during health that a variation of more than a single degree denotes some disturbance in the system; a fall of two degrees below the normal temperature is considered a serious matter; while a severe cold may cause it to rise two degrees above normal. A temperature above 103° denotes a high fever; of 105°, a severe attack; above 105° is most alarming; while recovery after the temperature has reached 110° is very rare.

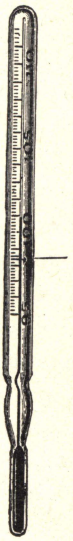


FIG. 78. — Clinical thermometer: the mark indicates 98½° F., the normal temperature of the healthy body.

The normal temperature of 98½° F. is subject to some variations within narrow limits. There are quite regular variations in the course of every twenty-four hours.

The temperature continues to rise during the day until it reaches the highest point from five to eight in the evening; then it continues to fall during the night until from two to six in the morning, when it is at the lowest. About the middle of the forenoon, or about three hours after the morning meal, the thermometer should record $98\frac{1}{2}°$ F. The difference between the lowest and highest points reached during the day usually does not exceed one degree.

The Regulation of Heat. — The question now arises, How is the excess of heat above $98\frac{1}{2}°$ removed from the body? The body would soon become very much warmer were not some means provided for regulating the heat. It is estimated that an adult body produces, in one hour, enough heat to raise the temperature three degrees. If no heat were given off, in thirty-six hours the temperature would reach the boiling point; hence the distribution and removal of the excess of heat becomes an important matter.

The two principal tissues which regulate the temperature are the lungs and the skin. It has been stated that the expired air is warmer than the inspired air. Therefore considerable heat is evidently carried out of the body with each expiration. The evaporation of the water of the expired air — the watery vapor — also produces cold; in fact, the loss of heat is in definite proportion to the amount of air taken into the lungs in a given time. The rapid breathing of a dog after running and the extra flow of water from his mouth are illustrations of these facts.

But the work of the skin is far more important, being five times as great as that of the lungs in this particular. It must be evident that the more freely the blood passes

through the skin, thus coming under the influence of the cooler surroundings of the body, so much the greater will be the loss of heat. The evaporation of the perspiration results also in a great loss of heat to the body.

This regulation of the heat is well illustrated by studying the changes which take place during active exercise. Muscular contraction gives rise to heat; hence exercise must increase the bodily temperature. But the thermometer shows no such change; what then becomes of the heat thus produced? The exercise causes rapid breathing, and hence more loss of heat through the lungs; while more blood is sent to the skin, where its temperature is lowered. The exercise also causes the skin to perspire freely, and the evaporation of the water from the surface of the body results in a great loss of heat. Thus we find that the extra amount of heat caused by muscular exertion is thown off by the increased action of the lungs and skin; and as a result, the temperature of the body remains at a fixed point.

Effects of Lowering the Temperature. — The body is warmed by heat generated within itself. To lower its temperature, it is only necessary to abstract the heat faster than it can be produced. The first effect of this is pain in the more exposed parts. The face and extremities "ache with the cold." This soon passes away and the skin becomes quite insensible. The testimony of persons who have been rescued from freezing, even after they were insensible from the cold, is that an inclination to sleep overtakes them soon after the pain has left the skin; the muscles become inactive; breathing is slow and difficult; and the whole nervous system becomes sluggish. Finally, the desire to sleep becomes irresistible, and in a short time death ensues. In the case of those who have

been rescued from a freezing condition, it has been found that the respiration is hardly perceptible, the heart's action extremely weak, and all the functions of the body nearly suspended.

The above condition is very similar to that of the so-called hibernating animals. These animals go to sleep at the approach of winter, and do not waken until the coming of spring. When found, buried in their nests, or deep underground, they are quite insensible and immovable. Their respiration is hardly discernible, and their bodily temperature is much reduced. The oxidation of tissue is very slight, and the animal appears to live by using up its own flesh, — entering upon sleep well supplied with fatty tissue and awakening in the spring very thin and poor.

Effects of Raising the Temperature. — When the animal heat is raised a number of degrees, as in fevers, the effects are quite the reverse of those produced by cold. In fevers, the pulse and the respiration are increased in frequency, and instead of a feeling of comfort and sleep, there is often much distress and wakefulness. Increased temperature appears to hasten the normal changes taking place in the tissues ; oxidation is more rapid, the tissues are more quickly exhausted, and the vitality is lowered.

Winter and Summer. — The moderate cold of winter imparts a feeling of vigor and stimulates the whole system. The cool air excites a desire to run, and to exercise the whole body ; this activity adds to the amount of heat which is necessary to resist the cold. Without exercise, the internal heat must be preserved by additional clothing, or the depressing effects of cold will be experienced. Cold weather brings a good appetite ; the extra amount of food is so much more fuel, contributing to the maintenance

of the animal heat ; thus we learn that a healthy body always demands more food during the winter than during the summer. Muscular activity, extra clothing, and more food enable the body to resist the cold and still maintain its average temperature. During the heat of summer less food is required and more liquids are used, the perspiration is increased, and the clothing is lighter, all of which tend to diminish the supply of heat and to increase the means for its escape.

The Effects of Alcohol on Temperature. — The feeling that alcohol warms the body is among the deceptions that follow its use. What it does do is to cause the minute blood vessels of the skin to become distended and an increased amount of blood to flow to the surface of the body. The blood as it comes from the interior is warmer than that near the surface ; therefore, when an extra amount flows to the surface at one time, it makes the skin feel much warmer. It is this that makes the person feel warmer, but in reality he is losing heat ; for an unusual amount of heat is being given off by the blood at the surface.

The period during which the skin feels warmer is very brief, while the period of cold following is of much longer duration. During the second period there is a fall of temperature proportionate to the amount of alcohol taken and the degree of cold to which the person is exposed. If the amount taken is sufficient to cause prolonged sleep, there may be a considerable reduction of temperature. In normal conditions, when a person is exposed to unusual cold, the blood vessels of the skin contract, allowing less blood than usual to approach the surface and become cooled. The action of alcohol interferes with this provision of nature.

Explorers in Arctic regions and travelers in cold countries are perfectly agreed that alcohol increases the suffering and danger from exposure to extreme cold. Their testimony is all to the effect that the use of alcohol in cold countries is extremely hazardous. The same principle applies to exposure to unusual cold in more temperate climates, and shows the fallacy of drinking alcoholic liquors to "warm one up," or to aid in keeping one warm on a cold day. They only make exposure to cold more dangerous. The men who never use alcohol bear such exposure much better and do their work more easily than those who take it.

Dr. J. Johnson, the Honorary Physician to Bolton Infirmary, England, says: "The verdict of medical science is emphatic enough, for it tells us that alcohol is in no real sense a food, and that the idea that these drinks strengthen the body is a complete fallacy. This is confirmed by the practice of all our great athletes, — swimmers, wrestlers, 'strong men,' boat racers, scullers, runners, cyclists, cricketers, and the most sensible foot-ballers, — who all train without alcohol, and abstain from it before and during the performance of their feats. Why? Because they know that it is a broken reed to trust to, a false friend, who is sure to fail them in their hour of need. . . . Every cyclist knows that he can go farther and faster without alcohol than with it, and that beer, often a single glass, will 'take the steam out of him.'"

Dr. E. Stuver states: "Alcohol lowers muscular force and efficiency. This is conclusively shown by the fact that those who engage in athletic sports must stop drinking if they expect to excel. No prize fighter, ball player, oarsman, or any other kind of athlete can keep up drinking habits without so injuring himself in a few years that he is relegated to the rear as a back number."

CHAPTER XXI

THE ANATOMY OF THE NERVOUS SYSTEM

Two Systems. — The nervous system consists of two great parts, the cerebro-spinal system and the sympathetic system. Each system has its nerve fibers and cells, and its collections of nerve cells, called nerve centers. Although these two great systems have their independent work to do, yet they are closely connected by many delicate nerve fibers.

The Cerebro-spinal System. — The cerebro-spinal system is composed of the brain, the spinal cord, and the nerves which originate from them. The brain and the spinal cord are the great nerve centers of the body. They are connected with the nerves of the special senses and with the nerves of common sensation; they convey to the mind the sensations of taste, touch, sight, smell, and hearing, as well as the sensations of pain, hunger, and thirst. The mind, in turn, expresses itself through them. Through the cerebro-spinal system the commands of the mind are conveyed to various parts of the body; thus, we "will" to move a muscle; instantly a command is sent along the nerves of this system to the proper muscle, and it promptly obeys (Fig. 79).

The Sympathetic System. — The sympathetic or ganglionic system consists of a number of **ganglia** and **nerve fibers.** The ganglia may be very small, composed of only a few cells, and visible only under the microscope; or

they may be large enough to be seen with the unaided eye. These ganglia are placed at the sides and front of the whole length of the spinal column. They are joined together by means of nerve fibers. Nerve fibers also connect these ganglia with the brain and spinal cord. Other nerves proceed from these same ganglia to all the organs in the thoracic and abdominal cavities.

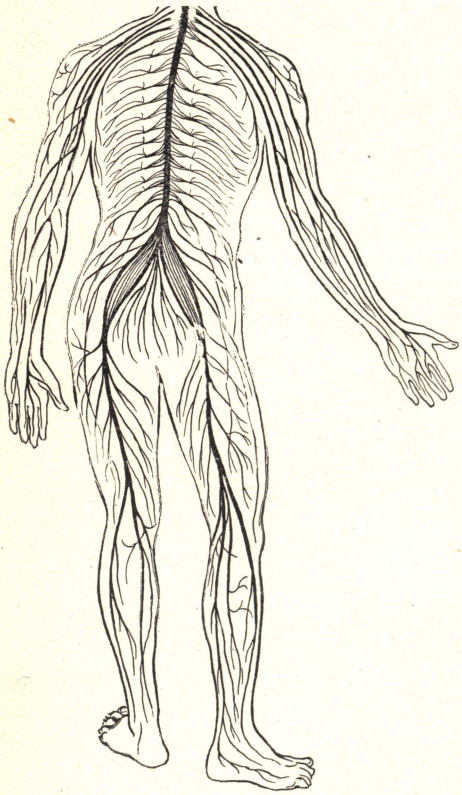


FIG. 79. — A diagram of the cerebro-spinal system.

The sympathetic nerves do not go to the skin, neither are they connected with the special senses, nor are they under the control of the will. This system presides over the involuntary processes of the body; such as the circulation, the digestion, the respiration, the absorption, the nutrition, and the involuntary muscles. It also controls the secretions of glands, and has much to do with the amount of blood distributed to the various organs and tissues.

Nerve Tissue. — There are two kinds of nerve tissue. Both are found in the cerebro-spinal and in the sympathetic systems. One tissue is composed of nerve fibers, and the other of nerve cells. The presence of numbers of the nerve cells gives a gray color to the tissue, while the nerve fibers appear white. Hence, an accumulation of nerve cells is called the **gray substance**, and a collection of nerve fibers is called the **white substance**. The nerve cells represent the centers of activity from which the orders are issued. The nerve fibers are simply the conductors, conveying the messages from place to place. The gray substance, therefore, represents the seat, or origin, of the mysterious forces of the nervous system; while the white substance represents only so many fibers for the transmission of the forces.

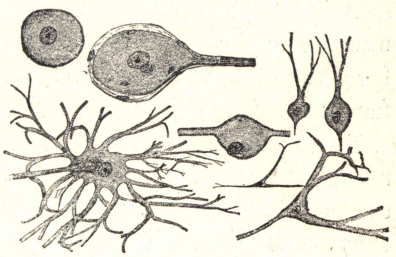


FIG. 80. — Various forms of nerve cells, highly magnified.

The Nerve Cells. — The greatest collection of nerve cells is found in the gray matter of the brain, the next in the spinal cord, and the next in the ganglia of the sympathetic system. Nerve cells generate nerve force. They also receive it from other cells and give it out again. They are therefore generators and transmitters of nerve force.

The cells vary exceedingly in size and shape. Some are of a circular form, as at the upper left corner of Fig. 80. Others have a long process extending from them, as shown in the cell to the right of the circular cell. This one process represents the beginning of a nerve fiber, so that nerve force originating in the cell can be conveyed from it

through this fiber to some distant organ or tissue. Other cells have many processes, only one of which conveys nerve force to the distant parts.

The Nerve Fibers. — The nerve fibers convey impressions to their nerve centers. If the end of a nerve fiber is affected (as, for example, when a finger is touched), a vibration is set up in the nerve fiber, and by this vibration the report of what has happened is conveyed along the nerves to the proper nerve center, which may be in the brain, or in the spinal cord. There the report thus sent is acted upon in some way; it may be that an order is sent by the brain over another line of nerves to a set of muscles in the hand, telling them to pull the hand away from the object touching it. All this happens rapidly; so fast, indeed, that it seems to be instantaneous.

Two Kinds of Nerve Fibers. — To understand better this action of the nerves, compare the nerves and the telephone system as we see it in daily operation. In many ways they work alike. There is one important point of difference: a message may be sent over a telephone wire in either direction; it is not necessary to have one wire over which to talk to Central and another wire over which Central can reply. In the case of the nerves, two complete sets of nerve fibers, or wires, are required. One set conveys sensation from the outer parts toward the nerve centers; while the other set conveys instructions from the nerve centers outward to the muscles.

The first set is composed of nerve fibers called **sensory fibers**, because they convey sensations to the spinal cord and brain; the other set consists of fibers called **motor fibers**, because they convey the stimulus of motion from the brain and spinal cord to the muscles. So far as is known there is no difference in the structure of these

fibers, and as a rule they are side by side throughout the body.

A nerve, as seen in the body, consists of a large number of these nerve fibers held together by a delicate connective tissue. Each nerve fiber extends the whole length of the nerve, from its beginning in the brain, or spinal cord, to its termination.

The Brain. — The brain is situated in the cranial cavity, or the skull. It is surrounded by three distinct mem-

FIG. 81. — Side view of the whole human brain: (1) cerebrum; (2) cerebellum; (3) medulla.

branes, of which the middle one is capable of secreting a fluid. The membranes protect the brain from friction against the bony walls, while the watery secretion gives it some slight freedom of motion and protects it from the effects of jars or of concussions from without. The brain is well supplied with blood by large arteries entering at the base of the skull.

The weight of the brain depends partly upon the size of the individual, and partly upon his intellectual capacity. The average weight of the brain of an adult male is a trifle over three pounds, 49½ or 49¾ ounces. The brains of idiots are very light, weighing from twenty-seven ounces to as low as eight ounces.

The brain is divided into the **cerebrum**, the **cerebellum**, and the **medulla oblongata**.

The Cerebrum. — The cerebrum is the brain proper. It is the part above the ears, and is familiarly known as the *great brain*. It is believed that the cerebrum is the organ of the mind; that it is here we think, know, and reason. The cerebrum is divided into two parts by a natural fissure which passes from the front backward. At the bottom of the fissure, the two parts are united by a band of nervous tissue. From this it would at first appear that we have two brains corresponding to the right and left sides of the body; but doubtless the band of union between them not only connects the structure of the two, but also in some way unites their functions.

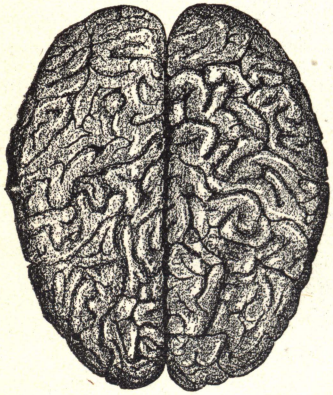


FIG. 82. — The human brain, viewed from above: only the cerebrum is seen, with its deep fissure nearly dividing it.

Figs. 81 and 82 show that the surface of the human brain is not smooth, but is thrown into a number of ridges or **convolutions**. The brains of many animals also have ridges, but the number of convolutions, and the depth to which they reach, varies in the different animals. In

some, the surface is perfectly smooth, as in the fishes, reptiles, and birds (Fig. 83); in others, the convolutions are shallow and few in number; in man, they are many and very deep. It is reasonable to suppose that the gray matter alone of the brain is connected with the intelligence of the animal. This is difficult to prove; but as a rule, the more intelligent the animal, the more numerous and the deeper are the convolutions of the cerebrum.

Gray and White Matter of the Cerebrum. — The gray matter is on the outside of the brain; the white matter is within, forming the center of the brain. The white matter is raised in slight folds on its surface to form the center of the convolutions; but the bulk of the convolutions is formed by the gray matter. It has already been stated that the gray matter consists principally of nerve cells, and that these cells are the active agents in originating, receiving, and sending forth orders. The cells command, and the fibers obey; the cells originate, and the fibers carry the messages. Since the cells are specially concerned in originating and commanding, it is evident that a large amount of the gray matter is most desirable.

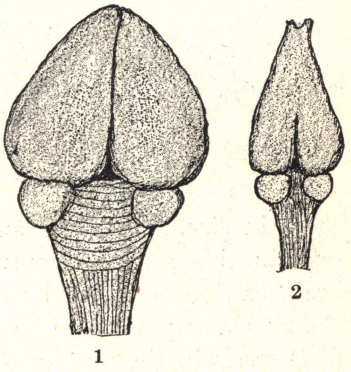


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FIG. 83. — (1) The brain of a pigeon; (2) the brain of a frog, — both viewed from above. There are no convolutions on the cerebrum.

The convolutions provide for this extra amount of gray matter. This is made clear by the diagram in Fig. 84. Suppose the surface of the brain were smooth, and covered with a layer of gray matter, then the line from

A to B would represent the extent of the surface. But when the layer of gray matter is thrown into folds, or convolutions, then the amount of surface is represented by the line 1 to 2. It is at once clear that the line 1 2 is much longer than the line A B. In other words, the convolutions greatly increase the amount of gray matter. It follows, therefore, that the deeper the convolutions and the greater their number, the more gray matter there will be. This anatomical fact may explain why some small brains are more intellectual than others which exceed

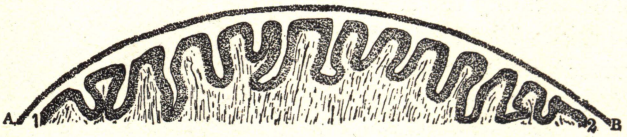

FIG. 84. — A diagram illustrating that the convolutions of the brain give more surface for the gray matter.

them in size. There is another fact that may help to explain this seeming contradiction. The power of the brain can be increased by training and exercise, much as the muscular power can be increased. There may also be differences in the quality of brain material, though little is yet known about this.

The Cranial Nerves. — There are twelve nerves given off from each side of the brain, each nerve supplying some part of the body on the right or left side.

One nerve, the *olfactory*, goes to the nose, and is the nerve for the sense of smell.

Another nerve, the *optic*, goes to the eye, and is the nerve for the sense of sight.

Another nerve, the *auditory*, passes to the ear, and is the nerve for the sense of hearing.

Still another nerve, the *pneumogastric*, or *vagus*, supplies the larynx, lungs, heart, stomach, intestines, and liver. It is an important,

PLATE VII

Some of the more important parts of the nervous system: (1) cerebrum; (2) cerebellum; (3) medulla; (4) spinal cord. From the lower part of the spinal cord a large nerve is given off, for each side of the body, called the sciatic nerve; it extends down the inner side of the back of the thigh (5). (6) Median nerve; (7) radial nerve; (8) ulnar nerve; (9) pneumogastric nerve, which comes from the brain. In the thoracic cavity it gives off branches to the heart (*H*); in the abdominal cavity, to the stomach (*S*).

large nerve, and passes down the side of the neck close to the carotid artery. For its location, see Plate VII.

Some of the cranial nerves are only motor nerves, others are only sensory nerves, while still others are both motor and sensory nerves.

The Cerebellum. — This part of the brain is situated beneath the back part of the cerebrum, and is often called the *lesser brain*. It consists of gray and white matter arranged in the form of parallel ridges and furrows running over its surface, as represented in (2), Fig. 81.

The Medulla Oblongata. — The **medulla**, as it is generally called, is situated at the upper end of the spinal cord, between the cord and the brain. It represents an enlargement of the upper part of the spinal cord, see (3), Fig. 81. It is well protected in the thick bones at the base of the skull. The functions of the medulla, such as the control of respiration, of swallowing, and of the action of the heart, are so necessary to life that it must be regarded as the most vital portion of the entire body; yet it is only about one and one fourth inches in length.

The Spinal Cord. — The **spinal cord**, as illustrated in Fig. 79, represents the elongated part of the cerebro-spinal system. It is about eighteen inches in length, one half an inch in thickness, and is nearly circular in shape. It is surrounded by three membranes which are continuations of those surrounding the brain, and is well protected in the spinal canal of the vertebral column. It begins at the medulla,

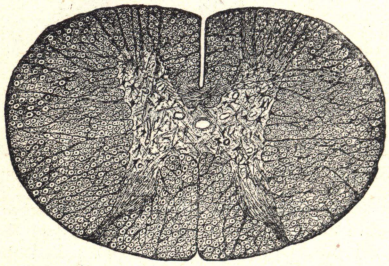

FIG. 85. — A cross section of the spinal cord, magnified.

and terminates at the lower end of the spinal column in a number of fine threads, as illustrated in Fig. 79. It is, like the brain, divided into halves by deep fissures. One fissure extends down the front of the cord, and the other, which is opposite it, extends down the back of the cord. Between them, they nearly divide the cord into two parts. Fig. 85 illustrates these fissures; the one in front showing more clearly than the other. An open central canal is also seen.

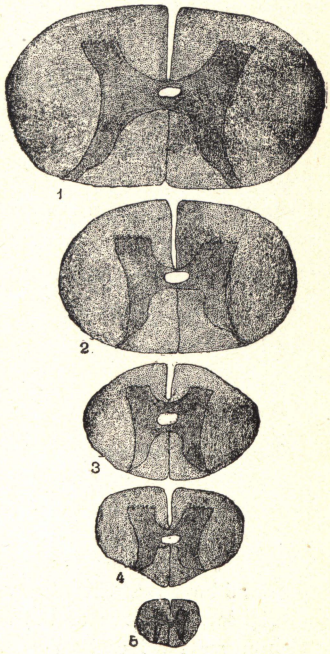

FIG. 86. — Cross sections of the spinal cords of different animals, represented as twice the natural size: (1) horse; (2) ox; (3) man; (4) hog; (5) squirrel.

White and Gray Matter of the Spinal Cord. — The gray matter of the cord is in the center. It is so arranged that when the cord is cut transversely, the gray matter slightly resembles the letter H. The darkly shaded portions in Fig. 85 illustrate this fact, and it is also shown in Fig. 86.

Outside the central gray matter is the white matter, which is composed of fibers. The fibers extend up and down the cord, so that a cross section of the cord, as seen in Fig. 85, shows the fibers to be circular and white, with a dot or dark spot in the center. This dark spot represents a cross section of that part of the gray nerve fiber which transmits the nerve force; the white substance around it is for insulation and protection.

These fibers finally enter the brain and are distributed to all parts of it, being at last connected with the nerve cells.

The Spinal Nerves. — There are thirty-one pairs of spinal nerves; each originates in the spinal cord by two roots. One root, the **anterior**, consists of motor fibers; it originates from the anterior part of the gray matter of the cord, as illustrated at (1), Fig. 87. The other root is composed of sensory fibers; it originates from the **posterior** part of the cord, as shown at (2). Both these roots unite to form one nerve, at (3). On the posterior root is a **ganglion**, (4), or a collection of nerve cells. The nerve fibers, at (3), continue together as a spinal nerve until they reach the distant parts of the body, when they separate again. Those fibers which originated from the anterior part, known as motor fibers, terminate in muscles; while those from the posterior part, known as sensory fibers, terminate in the skin.

The spinal nerves leave the spinal canal through openings between the vertebræ; after leaving it, they divide again and again until their minute branches extend to all parts of the body. Should one of these nerves be cut or be severely injured, all power of feeling and of motion would cease in the parts of the body supplied by that nerve. We would say that the parts were paralyzed.

The largest nerve of the upper extremities is the *median* nerve. This nerve receives its name because it extends down the median line, or the middle, of the whole length of the arm. Some of its fibers extend to the very tips of the fingers.

The largest nerve of the lower extremities is the *sciatic* nerve. It is also the largest nerve in the body, being nearly an inch in breadth. It extends down the whole length of the back of each leg.

CHAPTER XXII

THE PHYSIOLOGY OF THE NERVOUS SYSTEM

The Nerve Current. — We have already learned that the nerve fibers may be set vibrating, and that in this way they make their reports to the brain or the spinal cord. Just how this is done is not yet known; and there is also much about the most common forms of vibration, that of a telegraph or telephone wire, for instance, that is not understood. We know that the vibration travels along the nerves at the rate of over one hundred feet a second. We know, too, that every form of vibration must be started in some way. We call the force or the agent that starts a vibration, the *stimulus*. Suppose there is a desire to move the hand: in this case the stimulus is an act of the will, which excites the nerve current, so that it almost instantly passes down the nerve fibers to the muscles of the arm. When the nerve current reaches a muscle, the current itself acts as a stimulus, rousing the muscle to action. If we pinch the skin, the stimulus is a mechanical one; the sensation is carried to the nerve centers over the sensory fibers. If a bright light is brought near the face, the pupil of the eye becomes smaller: in this case, light is the stimulus which at last causes the muscles of the eye to contract. A sharp scream will cause a person to jump; here fright is the stimulus.

Function of the Cerebrum. — In the cerebrum are the nerve currents which control our thinking, feeling, and

willing. It is not known how the mind is connected with the brain, nor how the brain tissues control it; still we do know that if any of the nerve centers in the cerebrum are injured, the normal activity of the mind is interfered with. An injury to the head, resulting in a portion of the skull being fractured and pressed upon the brain, has been followed by loss of consciousness; and the person has remained in a deep sleep until the surgeon has raised the depressed bone, when consciousness has returned.

The mental state is also sometimes deranged by sickness; for example, an inflammation of the membranes of the brain, affecting its surface, causes delirium and otherwise disturbs the mind. Medicines which affect the flow of blood to the brain also interfere with the reasoning faculties. Persons born with extremely small brains have little intelligence. If the cerebrum be removed, all voluntary acts are abolished. Thus the evidence from the results of injuries, disease, drugs, and special experiments all show that a healthy condition of the cerebrum is necessary for the existence of intelligence and the power to will and to command.

Localization of the Brain. — We have learned that the gray matter of the cerebrum is composed largely of cells. All of these cells do not act at one time for one particular purpose. Certain cells or groups of cells, called "nerve centers," act for one purpose, another group for another purpose, and so on. To illustrate: When we look at an object the brain tells us concerning it, but only a few nerve cells are involved in this, and these cells make up the "center" for sight. This center has nothing to do with hearing or any of the other special senses. Each of the special senses has its own center in the brain. There are also many other centers, as the center that controls

the speech, and centers for the movements of the limbs. From this we can readily understand how some small part of the brain may be injured or diseased and thereby affect only one center. Thus, a person might be able to walk and think and write, but be unable to speak, because of trouble in the brain with the speech center. From this we conclude that the brain may to a certain extent be mapped out into spots, or places; it may be localized.

Two Brains. — As stated in the preceding chapter, the cerebrum is nearly divided into two complete parts. This fact has led some physiologists to declare that there are two brains, and that they act independently of each other. It is nearer the truth, probably, to say that so far as the mind is concerned, the two sides of the cerebrum should be considered as one organ, but that each side controls the sensation and motion of the opposite side of the body.

Mind and Body. — In some mysterious way, the mind and the body are so connected that what affects the one, affects the other also. Experiment has shown that there cannot be a normal mental condition, without a normal condition of the cerebrum. If we would attain the fullest intellectual development, attention must be given to the laws of health, and their teachings strictly obeyed.

Function of the Cerebellum. — Injuries to the cerebellum do not necessarily interfere with either the will or the consciousness, but they do interfere with the movements of the body. The cerebellum is especially concerned in maintaining a harmony of action of the voluntary muscles. By its action we are able to hold a position when taken; and at all times can have the muscles act in harmony and with regularity.

Functions of the Medulla. — This part of the nervous system is one of great interest. It is most essential to

life, and, as has already been stated, it controls many of the most important functions. In the medulla are many "centers" or small collections of nerve cells. When these centers are stimulated in any way, they put into action the functions they control; as, for example, there is a "sneezing center." If some irritant be inhaled into the nose, the ends of the nerve fibers are irritated and an impression is conveyed to the sneezing center; from this center goes forth a nerve current to certain muscles, which contract and cause the expulsive act of sneezing. Besides the sneezing center there are many others, among which are the coughing center, the center for the secretion of the saliva, the swallowing center, and the center for the closure of the eyelids.

One of the most important centers is known as the **respiratory center.** It is a fact that a small collection of cells in the medulla controls absolutely all the movements of respiration. This small center has greater power than the will itself; for we may "will" not to breathe, and we may make the attempt to hold the breath, but soon we can do so no longer. Notwithstanding our greatest efforts, we again begin to breathe; for the center in the medulla is stronger than the will. We may be capable of increasing or diminishing the number of respirations per minute for a short time, and may even cease breathing for a brief period; but soon the respiratory center exerts its power, and respiration is continued with wonderful regularity.

Other important centers affect the movements of the **heart.** One center continuously holds the heart in check, causing it to beat with great regularity. Another center appears to have an opposite effect at times, being capable of accelerating the action of the heart.

No less important is the **vaso-motor center.** This con-

trols the nerves which go to the entire arterial system. It is a small collection of cells, yet it is capable of causing the contraction, or relaxation, of the walls of any of the arteries. It will be remembered that in the walls of the arteries is a layer of involuntary muscle, arranged in a circular manner around the vessels; if the muscle contracts, the vessel will be narrowed; while if it relaxes, the vessel will be enlarged. The vaso-motor center presides over the action of the muscular walls of the arteries: the normal condition of this center is one which keeps the arterial walls in a moderate state of contraction at all times. The center is said to keep up the "tone" of the arteries, thereby keeping their walls firm and strong. When the function of this center is checked, it releases its hold on the arterial walls and they relax, thus enlarging the size of the vessel. If the blood vessels are thus made larger, more blood will flow through them, and the parts will be a deeper red in color. This is usually temporary, but it may become permanent.

This power of the vaso-motor center is most essential to the preservation of health, and even of life itself. Let us illustrate its daily action: the cold weather of winter stimulates the center so that it acts with increased power; this contracts the arteries of the skin, so that the flow of blood through it is greatly diminished. The loss of animal heat is thereby diminished, as we have already learned. But during the summer the vaso-motor nerves relax their hold on the smaller blood vessels of the skin; the blood flows more freely through it, and the loss of heat is thereby increased.

The vaso-motor center, therefore, is capable of controlling the supply of blood to any part of the body. By increasing its normal function, the arteries of any part are

made smaller and the supply of blood correspondingly less; while by diminishing its normal work, the arteries are made larger and the supply of blood increased. From all this it is easy to understand that the medulla is a most important, as well as a most delicate part of the nervous system.

It is also true that the sympathetic system has power to control the size of the arteries.

Injury to the Cord. — If the spinal column were very severely injured at a certain point, then all communication between the nerves below that point and the brain would be cut off. To illustrate: Suppose the spinal column were severely injured at the small of the back. Then if the feet were pinched or pricked, the pain would not be felt by the brain, for the line of communication would be cut. Neither could the brain send down a message to these nerves to have the foot moved away from the thing that pinched, for the same reason. All parts below the injury would be partially or completely paralyzed.

The Spinal Cord and Reflex Action. — The spinal cord is the **conducting medium** between the nerve fibers of the body and the brain.

A second function of the cord is a reflex one. It is a great **reflex center**; its action in this respect is almost continuous. There are many familiar illustrations of this action in everyday life; tickling the foot of a person who is asleep causes the foot to be quickly withdrawn; this is purely a reflex act. The impression produced on the nerves of the foot is conveyed along the sensory fibers to the spinal cord, and from the cord it is "reflected" outward along a motor nerve to the muscles of the leg. The sensation produced by the tickling entered the cord

through the posterior root of a spinal nerve, and immediately left it through the anterior root; this involved no interference of the brain. This is shown in Plate VIII.

To make a reflex act, three things are necessary: an unbroken sensory nerve, for connecting the point touched with the nerve center; a healthy nerve center; and an unbroken motor nerve between the nerve center and the muscles to be stimulated. Reflex action is partly, but not altogether, under the control of the will. To illustrate: if we inhale an irritating powder, like pepper, through the nose, we may be able to postpone the sneezing for a short time, but finally we are obliged to sneeze, and no power of the will can prevent it.

Course of Nerve Current in Reflex Action. — A glance at Fig. 87 will make clear the course of the nerve current in a reflex act. At the right, (3), is one of the spinal nerves. This large nerve consists of many fibers which proceed together until they reach some part, as the arm. There some of the fibers terminate in the skin and others in the muscles. If the skin on the arm be touched, the stimulus will be conveyed toward the spinal cord and will finally enter it through the sensory root, at (2). The nerve current then goes directly through the gray matter to the anterior or motor root, at (1); it then passes down the motor fibers, which are alone at (1), but which are soon side by side with the

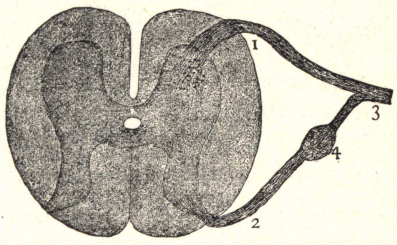

FIG. 87. — A diagram illustrating the origin of the spinal nerves from the spinal cord. (1) and (2) unite to form (3), a spinal nerve: (1) is the motor root; (2) is the sensory root: both originate from the gray matter of the cord. (4) is a collection of nerve cells.

sensory fibers in the spinal nerve, at (3). After continuing the length of the motor fibers, the current finally stimulates some of the muscles of the arm and they respond by a vigorous contraction. Thus it is seen that the sensory and motor fibers are separated into distinct bundles at their beginning, and they are also separated at their termination, the former in the skin and the latter in the muscles; but they were together in one bundle through all the distance between. A reference to Fig. 88 may aid in making the subject more clear. The nerve current travels in the direction of the arrowheads.

Importance of Reflex Action. — The daily work of the body is carried on largely as a result of reflex action. The flow of saliva produced by mastication is a result of reflex action; we could not check the flow if we desired. The flow of the gastric juice, from the stimulus of food in the stomach, is purely a result of reflex action. Respiration is a reflex act, due to certain stimuli applied to the respiratory center in the medulla. The nervous system is constantly performing a vast amount of labor of which we are unconscious, and which we are unable to alter, except possibly to a limited degree in a few instances.

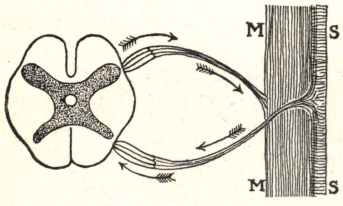

FIG. 88. — A diagram illustrating reflex action: S, the skin; M, a muscle. If the skin, S, be touched, the nerve current travels in the direction of the arrows until it stimulates the muscle, M, to contract.

Acquired Reflex Action. — Many acts which are at first voluntary, and are performed only by a strong effort of the will, finally become so natural and easy that they are performed unconsciously; these may be called **acquired reflex acts.** We all have to learn to walk, and it is at first

PLATE VIII.—FIGURE A. Illustrating an act of the will: (1), cerebrum; (2), cerebellum; (3), medulla; (4, 4), spinal cord; (5), sciatic nerve; (6), median nerve. The white lines represent that part of the nervous system which is involved in the act; the red lines the motor nerves that are called into play; and the black lines the sensory nerves.

The boy desires to balance the book on his thumb. The idea originates in his brain; the will stimulates a current in the motor part of the nerves, which passes down the brain, medulla, upper part of the spinal cord, and along the median nerve. When this nerve current reaches the flexor muscles of the arm and hand, it causes these muscles to contract.

FIGURE B.—Illustrating reflex action, during which the brain is not involved.

The book accidently slipped and fell on the toes of the left foot. Instantly the foot is withdrawn before the brain even becomes aware that the book has fallen.

The blow of the book stimulated sensory nerves, thereby producing a nerve current which extended up the sensory nerve (illustrated by the black line) to a point where that nerve enters the spinal cord. The current enters the cord through the posterior sensory root, then passes directly across the cord, leaving it through the motor root (illustrated by the red line). The nerve current then passes down this motor nerve to the flexor muscles of the leg, which contract, thereby drawing the foot away from the book.

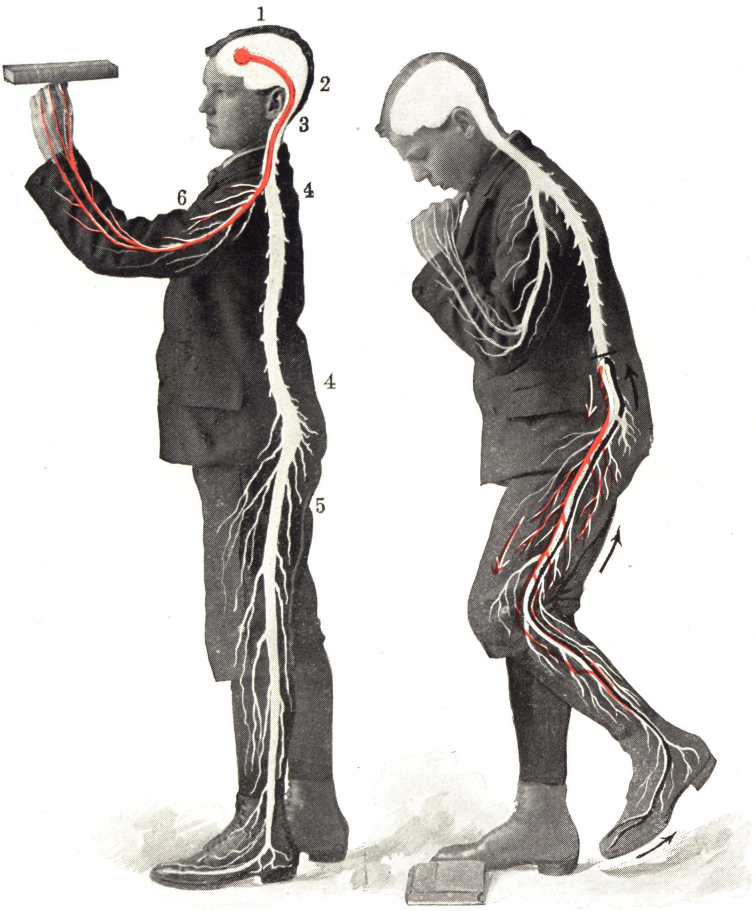

FIGURE A. FIGURE B.

PLATE VIII.

a very difficult process, accomplished with considerable effort. The number of muscles brought into play in running and jumping is very great; yet they all relax and contract at just the proper time, without the least aid from the will. When the beginner plays the piano, he not only looks at the music, but also at the keys, that only the right ones may be touched; but after a time the sight of a particular note calls forth such a movement of the hand that just the proper key is touched. The performer looks at the music, and the hands take care of themselves. The first trials at skating are not highly successful. All the power of the will has to be exercised to keep the balance and to move in the desired direction; but soon the movements become easier and the exercise becomes a pleasure and a rest.

Habit. — A **habit** is an action acquired by frequent repetition. It is a law in physiology that each time a nerve cell acts in a particular way, it gains a power that makes the second act more easily performed. In this way a habit is formed: it may be the habit of walking, of skating, or of playing the piano; it matters not what the acts are, provided the nerve centers become accustomed to their repetition. An effort of the will is necessary to form a habit; but, once formed, it takes another effort of the will to break it.

CHAPTER XXIII

THE HYGIENE OF THE NERVOUS SYSTEM

Necessity of a Healthy Nervous System.— Since all the functions of the body are dependent upon the activity of the nerve centers, it is easy to understand that these must be in the best condition, or the parts under their control will suffer.

Heredity. — When we recognize how strikingly children often resemble their parents in appearance and in disposition, it will not seem strange to us that scientists trace a still closer connection. They tell us that children of parents who are robust and vigorous, with sound nervous systems, under good control, are more likely to be free from physical and moral ills than are the children of those parents who have weakened their bodies, and particularly their nervous systems, by excess of any sort. This means that people ought to regard all the laws of health, and ought to follow the highest and best method of living, — for the sake of their children as well as for the effect on themselves. It does not mean, however, that the child who has weak or vicious parents must necessarily follow in their footsteps. Surely no boy would feel that because his father had a very bad temper he also must give way to anger and to ill feeling. He might be tempted to do so more frequently than the boy whose father or mother had a nervous system that was under better control ; but he could conquer that tendency. When such a boy masters

himself, he comes off a glorious victor. So no one need be discouraged if he starts with a physical or a mental handicap; he can triumph in conquering it.

A Healthy Body. — Even with a vigorous nervous system and a strong moral nature transmitted to us, all our bright hopes may be easily thwarted by neglecting to obey some of the well-known laws of health. To develop the nervous system requires proper food, pure air, and plenty of mental and physical exercise. Physical weakness is not conducive to good brain work; a tired body will not stimulate the brain to action; hence we conclude again that a healthy body is necessary for the highest and best development of the whole nervous system.

Exercise of the Mind. — As muscular exercise is essential to the full development of the muscles, so mental exercise is necessary if the best efforts of the brain are desired. This exercise must be regular, persistent, and properly suited to the age and health of the person. It is impossible for the boy to jump as far at the first trial as he will after weeks of practice; neither can he perform as severe mental work at first, as he will after months of constant study.

If the muscles have not been previously trained, one hard effort at lifting or running may cause severe pain and soreness in them. So an extra effort of the mind for one unaccustomed to study may cause headache and even severe mental disorders. The evils of over-study and of crowding too many studies into each school year are being more fully understood and corrected, while more attention is being given to a better understanding of the laws of health. The modern teacher knows that a pupil with a healthy body is far more likely to have a vigorous mind, and that the proper care of each should go hand in hand.

Mental labor ought not to cease with the school life; the school is to discipline and train the mind so that the powers of observation and reasoning may be used throughout life to the best possible advantage. "Work" is an important factor in maintaining a healthy body and a well-balanced mind, — regular, systematic, persistent work, for both the body and the mind. Pleasures are more enjoyable, and amusements are more profitable, if we make them but the short vacations in our daily duties. A life of utter idleness and pleasure seeking is not the normal condition of any human being. There should be a right proportion of work and pleasure in each day's programme.

Rest. — The mind, as well as the body, would soon fail if it were obliged to work too hard or too long. Rest is absolutely necessary for all parts of the body. Many individuals seem to think that rest means to fold the hands and remain in perfect idleness; as a rule, this is the poorest method of obtaining rest. If we have been exercising the mind until we are tired from study, nothing will restore the mental vigor better than some gentle outdoor sport, like a brisk walk. The exercise brings a good supply of fresh blood to the brain, and thus aids in giving new life to its tissue. The headaches of school children often cease before they have reached their homes at the close of day.

Some one has said that the only true vacation is a change of occupation — and there is a good deal of common sense in the saying. Amusements, excursions, and a change in the character of the work, all tend to repair the waste of nervous energy, and are far better than idleness. Complete rest and quiet are not conducive to health unless for particular reasons they have been ordered by a physician.

Worry. — Above all things do not worry. Study hard, play hard, enter with enthusiasm into all the duties and pleasures of school life, but do not worry. Worry means waste — waste of nervous force, of thought, of memory; and it is a sure road to the impairment of the highest functions of the brain. While it is true that some students do not have interest enough in doing their work, yet it is equally true, especially in the higher grades, that many attempt to accomplish altogether too much.

Sleep. — One of the great restorers of both mind and body is sleep. All animals having a well-developed nervous system take rest in sleep. Drowsiness and weariness warn us that sleep is necessary. These warnings may be unheeded for a time, but sooner or later we have to yield to the imperative demand. Some persons require more sleep than others, but the adult needs, on the average, from seven to nine hours of sleep daily. It is said that Napoleon required but three or four hours' sleep each day, and that he would pass days with very little rest of any kind. Frederick the Great required but little sleep, not over five hours a day. These are marked exceptions. Nearly all our great men who are obliged to do an immense amount of brain work sleep well and long: they know the value of a good night's rest, and are alarmed when they are unable to procure sleep. They know that during their busy days the waste is greater than the repair, and that during the quiet rest of the night the cells are busy repairing the waste, and appropriating new material for the labor of another day.

Insomnia. — Continued wakefulness often becomes a very serious trouble, and many men have lost their health by the inability to sleep. If the condition is persistent, it is best to consult a physician for relief, instead of taking

sleeping powders or any other quieting drugs on one's own responsibility.

To promote Sleep. — There are many popular ways of promoting sleep, nearly all of which make a bad matter worse. Out-door exercise during the day, light suppers, quiet evenings, and warm feet will greatly promote sleep. "Keep the head cool and the feet warm" is an old piece of advice worth remembering. To make sure of a good night's rest, the tired brain must be free from cares, griefs, and anxieties. Infants always require food before they are put to bed for the night, and young children may need a cracker, or some other light food.

We must remember that the brain works, and hence wears out like any other tissue; it must therefore be kept well supplied with new material. School children need plenty of plain, wholesome food, and an abundant supply of fresh air.

Students need much Sleep. — Students often make a great mistake in trying to change the laws of nature, by studying until late into the night, and then in sleeping away the morning hours. The sleeping room should be quiet, darkened, and supplied with cool, fresh air. At night the brain is tired, and an extra effort is necessary to make an impression upon it; in the morning it is fresh and sensitive and easily impressed, which proves that the morning is the better time for study. Earnest application in the early part of the day, concentrating the mind with all the power of the will, and laying aside everything else but the work in hand, — this will accomplish the best results from study, and leave the evenings for relaxation, and the nights for sleep.

Effects of Alcoholic Drinks upon the Nervous System. — When cells of different composition are brought into con-

tact with alcohol, it has been found that those most delicate in structure are the soonest affected. The cells of the nervous system are the most delicate of any in the body, and thus it is the nervous system that first shows the effects of alcohol, when any drink containing it has been taken into the body.

The first noticeable effect of alcohol upon the drinker is usually a flushing of the skin from the expansion of the small blood vessels. Quickly afterward follows a kind of mental excitement that has often been misinterpreted as an increase of mental power. The real nature of this effect of alcohol was not understood until it began to be studied by scientific investigation with exact methods and trained observation. Then it was found that the so-called exhilarating effect of a glass of wine or beer is an abnormal, unhealthful state, caused by the poisonous effect of the drug. After such a drink, a person cannot add a column of figures so correctly as before, he cannot commit to memory so well, he cannot give such close attention to any subject; his powers of observation and perception are weakened, — he thinks on a lower level.

In a healthy condition, the mind gains speed and skill by practice. Alcohol neutralizes the benefit of practice by reducing the mental operations to the untrained state preceding practice. Similarly, education, training, culture, refine the mind and increase it powers, enabling it to think upon larger subjects, to discriminate more closely, to see finer shades of meaning, to pay more attention to propriety of conduct. Alcohol wipes out these advantages, reducing the cultivated mind to the level of the uncultivated.

One of the most serious effects of alcohol upon the mind is its weakening of the power of self-control. Nothing is

more unfounded than the scorn one sometimes hears expressed of the person who, it is said, "does not know when he gets enough." Such a remark betrays ignorance of the power of alcohol to destroy self-control by weakening first of all that part of the body which alone can exercise self-control, the brain. The time for self-control is before the brain is injured, by refusing to take a drink of brain poison. As well expect a person to remain awake after taking a fatal dose of opium, as to expect a full measure of self-control from a man after he has taken a drink of any alcoholic liquor.

The foregoing applies to the effects of small doses of alcohol. The effects of the continued or habitual use of either large or small quantities is a gradual impairment of the brain and consequent weakening of all its functions. A series of experiments performed in Germany a short time ago proved that the effects of a single dose of alcoholic drink taken in the evening lowered the working ability the following day, and, if the dose was large, the second day also showed some bad results.[1] If the practice was continued for several nights, the working ability steadily declined for several days after the alcohol was stopped. Even then there was not complete recovery, for upon resuming the alcohol again the effects were worse than the first time the experiment was tried.

The fact thus established, that alcohol taken at night reduces working ability the following day, shows the mistake made by those who think they can take wine or beer or some other alcoholic drink with the last meal of the day, after their day's work is done, without being harmed by it. They are sowing the seeds of failure in their health and in their business, and the crop may mature in both.

[1] Kræpelin — Wiener Klinischer Wochenschrift, October 17, 1899.

The last stages of the effect of alcohol upon the nervous system are seen in the mental and moral wreck whose last hope is the inebriate asylum. He lies ruined and helpless at the bottom of an inclined plane whose top was his first glass.

In Germany, in the universities and other centers of learning where these important truths concerning the effect of alcohol have been tested and proved, students are banding together in abstinence societies to oppose the drinking customs that have so long prevailed there. The absurd treating and toasting customs of our country call for an equally courageous stand by every student who learns that it is the nature of alcohol to weaken the brain, enslave the appetite, and block the development of one's best and highest possibilities.

It is now a well-established fact that the disastrous effects of alcoholic drinks can extend farther than the drinker. It can make his children weaklings or defectives. Some one has said that every child has the right of being well born. The drinker should remember that by taking alcoholic drinks he is depriving his children of that birthright. Children who have the misfortune to inherit some of the evil consequences of parental drinking need particularly to avoid all use of alcohol and other narcotics, and to live as healthfully as possible in all other respects, in order to overcome the hereditary weakness.

Dr. A. H. Stehr, a German physician, in a recent work on the use of alcohol and academic work, says: "The injury to the working ability of the muscles is small compared to the injury to the brain, which is the chief organ of academic activity. The work of the student certainly places the highest strain upon his mental functions, because he is not following beaten paths but has to open new ones. He must be able to judge

causes and consequences, to verify unfamiliar mental productions, to trace clearly coördinate, subordinate, and causal relations. Later he will become one of the class from whom almost alone comes the creative work and thereby the condition of the progress of civilization in his country. The student from his boyhood must be free from the constraint to drink, which is a yoke upon so many German students. The drinking customs must be abolished by the knowledge that alcohol hangs like an iron weight upon all higher mental activity. Artistic ability is an activity of the imagination and intuition which, as Helmholtz's well-known remark puts it, is banished by the smallest amount of alcohol, while numerous poets and artists have emphasized the injurious effects of alcohol upon their productions."

Prof. J. J. Abel, of Johns Hopkins University, says, "Every man who, according to his own notions, is only a moderate drinker places himself by this indulgence on a lower intellectual level and opposes the complete and full utilization of his intellectual powers."

The Journal of the American Medical Association, 1902, said, "There is good testimony, not yet controverted, or even contradicted, that comparatively small doses of alcohol have a direct deleterious action on the nervous functions and the capacity for work."

R. Drysdale, M.D., writes, "Alcohol diminishes the capacity for muscular exertion by its paralyzing action, in which it resembles chloroform and ether. . . . The experiments of Schmiedeberg have shown that alcohol does not stimulate, but that it paralyzes and that its temporary excitation is caused, as in the case of chloroform and ether, by its paralyzing action on the brain, which is followed by convulsive movements, due to the other nerve centers, which continue until these also become paralyzed."

CHAPTER XXIV

THE SENSE OF SIGHT

Protection for the Eyes. — The eyes are well protected in deep sockets of bone, called the **orbits.** Externally they are protected by the **eyebrows,** the **eyelids** with their glands, the **eyelashes,** and the **lachrymal glands.** The nose is also a valuable protection (Fig. 89).

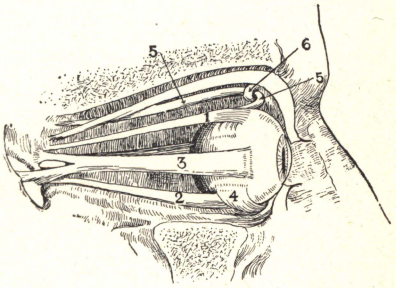

FIG. 89. — The muscles of the right eyeball. The outer bony walls of the orbit have been removed. (1) The muscle which turns the eyeball upward; (2) downward; (3) outward; a corresponding muscle on the inner side moves the eyeball inward; (4, 5) muscles which rotate the eyeball; (6) a pulley, through which the tendon of the muscle (5) moves.

The Eyebrows. — The eyebrows project over the eyes and are covered with a thick growth of hair. The hair is directed obliquely outward, so that the perspiration from the forehead is carried to the side of the face, instead of running directly down into the eyes.

The Eyelids. — The eyelids are curtains placed directly in front of the eyeballs. In the center of each eyelid is a thin plate of cartilage, on the outside of which is a thin muscle covered with skin. The inside of the lids is lined with a delicate membrane, called the **conjunctiva.**

On the edges of the lids is a row of delicate hairs, called **eyelashes.** They protect the eyes from insects and particles of foreign matter; for the moment any foreign bodies come in contact with the lashes the lids close, thus preventing the objects from touching the eyeball. The eyelids keep the heat and cold from the more delicate parts of the eye, and they also keep out an excess of light. Their most important function is to cleanse the eyes and to keep them moist. Their rapid and frequent movements thoroughly remove any particles of dust from the front of the eyeball, while at the same time they moisten the surface. This is the object of winking, which is usually a reflex act, although it may be made voluntary.

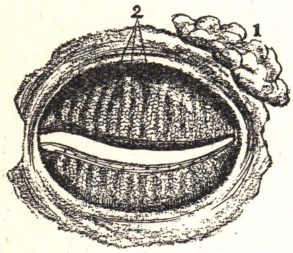

FIG. 90. — The eyelids of the right eye, viewed from the inside: (1) the lachrymal gland; (2) the oil glands in the eyelids.

The Oil Glands. — Oil glands are situated at right angles to the free edges of the lids, and on their inner side. They can be seen on the inner surface of the eyelids through the mucous membrane, looking like strings of minute pearls. They extend nearly across the entire width of the lids, on the edges of which they open and pour out their oily secretion. This keeps the lids from adhering to each other, and holds back the tears so that they do not under normal conditions run over the edges and down upon the face.

The Lachrymal Gland. — The lachrymal gland is an almond-shaped body placed in the outer and upper part of each orbit, between the eyeball and the bone. From this gland there extend about seven ducts or canals, which

open on the inner surface of the upper eyelid near its outer part. The openings are arranged in a row, as represented at (2), Fig. 90, thus distributing the secretion over the surface of the conjunctiva.

The Tears. — The watery secretion from the lachrymal glands is known as the **lachrymal fluid.** The secretion is a constant one, although we are unconscious of its presence until there is an excessive flow; the fluid is evenly distributed by the movements of the eyelids. An excessive amount of this secretion is called the **tears.** They are easily excited by irritants affecting the eye or nose; by laughing and crying, and by various mental emotions.

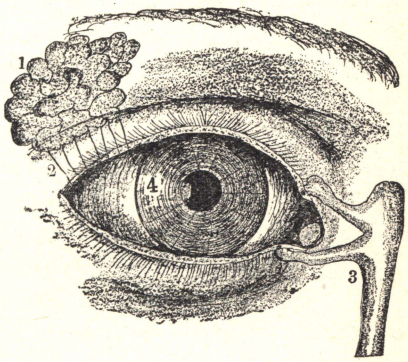

FIG. 91. — Front view of the right eye, showing the location of the lachrymal gland and the nasal duct: (1) the lachrymal gland; (2) the ducts that carry the secretion from the gland to the free surface of the eyeball; (3) the duct for the passage of the secretion to the nose; (4) the iris, in the center of which is the pupil.

Some of the secretion is evaporated from the eyeball, but the greater part of it escapes from the eye through regular channels provided for it. The secretion flows toward the inner angle of the eye, where it enters two openings, one in each lid. On the lower lid this opening is easily seen as a dark point in the center of a little eminence near the inner corner of the eye. These points, which look dark as all small openings do, are the beginnings of two ducts which pass inward toward the nose, as will be seen at (3), Fig. 91.

The Eyeball. — The eyeball is securely protected from injury and yet it has a most extensive range of vision. It is a round body, with the exception that its front part protrudes; and is about an inch in depth (Fig. 92).

The eyeball has three membranes or coats surrounding it. (1) The outer coat consists of two parts; the transparent **cornea**, through which the light passes into the eye, and the hard, thick part lying just behind it, commonly called "the white of the eye." Its scientific name is the **sclerotic.**

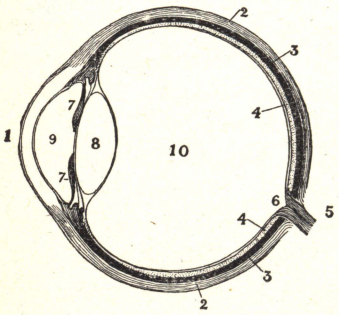

FIG. 92. — A section through the eyeball: (1) the cornea, or the transparent membrane which forms the front of the eye; (2) the sclerotic; (3) the choroid; (4) the retina; (5) the optic nerve; (6) the blind spot; (7) the iris; (8) the lens; (9) the aqueous humor; (10) the vitreous humor.

(2) The middle coat of the eye is called the **choroid**; it is filled with dark pigment which makes it look quite black. The choroid joins a membrane in front, called the **iris**, in the center of which is an opening, called the **pupil.** In the iris are the cells, containing a coloring matter, which give the characteristic color to the eye. The size of the pupil can be changed by the action of certain muscles: the muscles are involuntary so that they contract and relax only as a result of some influence outside of the will. A bright light will make the muscles of the iris contract so that the pupil becomes much smaller, and thus but little light reaches the interior of the eye. If the light be very faint, other muscles of the iris contract, enlarging the pupil, and thus allowing more light to enter.

(3) The third or inner coat of the eye is called the **retina.** The microscope shows that it has a most complicated structure, and that it is directly connected with the fibers of the optic nerve, which go directly to the brain. When light reaches the interior of the eye, it produces a peculiar impression on the retina; and by some means not known to science the brain receives the sensation of vision, or as we ordinarily say, we are able to see. When any object is viewed, the exact image of it is produced on the retina. If the optic nerve be cut, the image will still be formed, but no sensation of light will reach the brain. Just as in photography, it is the photographer who sees and not his camera, so it is the brain which sees and not the eye, for the eye corresponds to the camera.

Functions of Parts. — The eyeballs may be likened to a room, with a single window in front. Just back of the window hangs a dark curtain with a round opening in it. All light entering the room must come through the window, pass through the opening in the curtain, and strike the opposite wall. The transparent cornea is the window; the iris is the dark curtain for regulating the amount of light; the pupil is the central opening; and it is the retina that receives the impression of light. The choroid (the middle coat) is black to prevent the reflection of light within the eye, and to absorb any light which may pass through the retina. The sclerotic is hard and firm, for a protection to the eye and for the attachment of muscles.

The Blind Spot. — All parts of the retina are not equally sensitive to light. One spot on it, where the optic nerve enters (see Fig. 92, 6), is entirely insensible to light. This is called the blind spot: it does not interfere with vision, because it is impossible for the light from an object to fall on the blind spot of both eyes at once. If certain

rays fall on the blind spot in the retina of one eye, they will fall on a different part of the retina of the other eye. But if one eye be closed, there is always some portion of the object before us which is invisible. This is easily proved by looking at a sharply defined object after the following manner: close the left eye and look steadily at the small white circle to the left of Fig. 93: it is possible now to see the large white circle even when the eye is fixed on the smaller one. Hold the book vertically on a level with the eyes at a convenient distance. Now move the book slowly backward and forward. Soon a distance will be

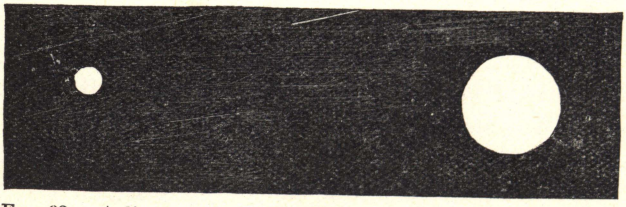

FIG. 93. — A diagram for illustrating the existence of the blind spot.

found where the large circle entirely disappears, only to reappear again as the book is moved nearer or farther from the eye. This is because the light from the large circle, when it entered the eye at a certain angle, fell on the retina just where the optic nerve enters.

Color Blindness. — **Color blindness** may be total or partial. When total, all objects appear gray. These cases are very rare. The usual cases of color blindness are those where the persons cannot distinguish between red and green. This is a serious defect, especially if occurring in engineers, who depend upon the green and red light signals at depots, railroad yards, etc.

Shortsightedness; Farsightedness. — In a normal eye, an image of all objects seen distinctly is formed on the

retina. If the eye is too deep, that is, if its diameter from before, backward, is too great, then the image is formed in front of the retina and appears blurred. If the object be held very near the eye, however, the image is formed on the retina and vision is distinct. As the field of distinct vision is thus limited to near objects, the defect is called near or **shortsightedness**. It is remedied by wearing concave glasses. In **farsightedness**, either the eye is not deep enough, or the lens may not be of the proper curve. This is quite a common defect after forty or fifty years of age. It is remedied by wearing convex glasses.

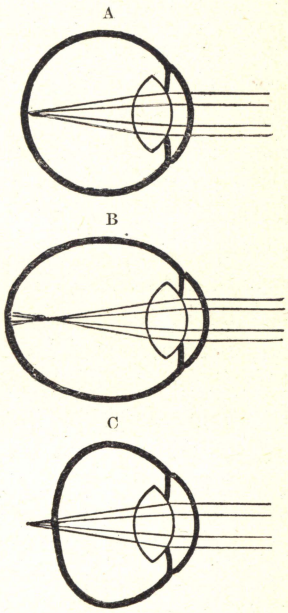

FIG. 94. — Diagrams illustrating the path of the light rays entering A, a normal eye, B, a farsighted eye, and C, a shortsighted eye. Notice how in the normal eye, A, the light focusses on the retina, and so the image resulting is a true image.

Care of the Eyes. — The eyes may look bright and clear, yet if their use in reading is followed by pain in the head, it is probable that there is some defect in vision. A clear and steady light is most desirable; a dim light makes it necessary to put forth an effort to see, while a strong light is equally harmful. Looking at the sun or any other brilliant light is positively injurious. The light should come from over the left shoulder, so that it may fall on the page of the book without coming directly into the face. Squinting, or looking cross-eyed, or rolling the eyes about, as is often done by children in sport, is a

dangerous thing, as some of the muscles of the eyeball may be severely strained by so doing.

To read while lying down, especially in bed, is a very unwise practice, as the eyes cannot focus naturally for reading when the body is in this position. The upright position is the natural and proper one for reading. The book should be held at twelve to sixteen inches from the face. Students are advised to notice their usual manner of reading and studying, at their desks and in their own homes. Many will find that they are forming habits which ought to be corrected. Those who cannot see ordinary type, unless the book is nearer than ten inches, should consult an oculist and ascertain whether it would not be better to wear glasses. Never rub the eyes, for any reason, especially if some particle of dirt has fallen into them; have all such objects carefully removed at once by some competent person.

Eye Strain. — When the image of an object is not formed distinctly on the retina, as in shortsightedness or farsightedness, the cause is usually a defect in the shape of the eyeball, which is roughly illustrated in Fig. 94. In such cases the image does not focus on the retina, as it should, see B and C, and the muscles of the eye make a constant effort to bring the focus right. This results in straining the muscles, thereby causing pain in the eyes, headaches, sick headaches, and other affections of a more serious character. Constant headaches should always send one to consult an oculist or a physician, to see if glasses are necessary.

Relation of Attention to Mental Growth. — We should not only take the best of care of our eyes, but we should also train them in order that they may serve us better. This may be done by cultivation of the power of atten-

tion, learning to notice objects about us quickly and accurately. Take a stroll through the woods or over the fields, count the different kinds of birds, note the movements of the squirrels, look at the flowers, the rocks, the brooks, and thus begin to learn how valuable the eyes are, when rightly directed, to the proper growth and development of the mind. In this way also we come near to Nature and learn better how to love all her wonderful works. Habits of quick observation and accurate description, formed thus early in life, will prove of great value in after years.

Injurious Effects of Alcohol and Tobacco. — Long-continued and frequent indulgence in alcoholic liquors may have a very serious effect upon the eyesight, resulting in degeneration of the optic nerve.

Several cases of degeneration of the optic nerve, from the use of cheap flavoring extracts put up with methyl or wood alcohol, have recently been reported. Some authorities have held that common or ethyl alcohol did not produce this disease, but a series of very careful microscopic examinations made a few years ago proved that in cases of chronic poisoning with ethyl alcohol, the same degeneration of the optic nerve resulted.[1]

Tobacco is a well-recognized cause of this disease. The edges of a smoker's eyelids are often inflamed as a result of contact with the irritating smoke. Frequently the smoker experiences sharp pains in the eyeballs, with more or less failure of vision.

One of the most serious results to the eyes from the use of tobacco is known as "smokers' blindness."

[1] Friendenwald — Johns Hopkins Hospital Bulletin, 1902.

CHAPTER XXV

THE SENSES OF TASTE AND SMELL

The Tongue. — The sense of taste is located in the **tongue**, in the back part of the roof of the mouth, and, to a slight extent, in the sides of the throat. The mucous membrane covering the upper surface of the tongue, however, is more especially the seat of this sense. The tongue is composed of voluntary muscle, covered with mucous membrane. In health, it is moist and of a light red color. Any marked change from this condition is an indication of some departure from health. Thus the appearance of the tongue often gives aid to the physician in ascertaining the source and character of the disease.

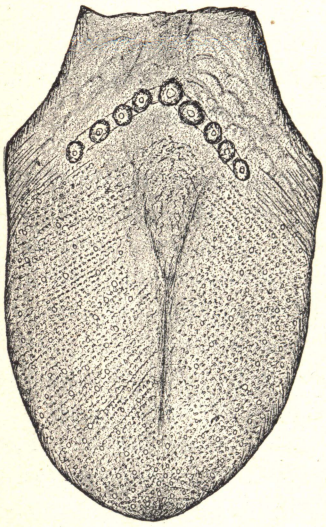

FIG. 95. — The tongue, showing the varieties of papillæ.

Papillæ of the Tongue. — The mucous membrane of the tongue is covered with a great number of **papillæ** (Fig. 95). There are three varieties on the surface of the tongue. The largest papillæ can be seen by the unaided eye; they are far back at the base of the tongue, arranged in the

form of the letter V, with the point of the V toward the back. There are eight or ten of these, each consisting of a central papilla surrounded by a wall. The second variety can also be seen with the unaided eye, and they are easily recognized by their deep red color. They are most abundant at the tip of the tongue, where they present a club-shaped appearance. The third variety is the most numerous of all. These papillæ are minute in size, conical in shape, and cover the front two-thirds of the tongue. They are of a whitish color, owing to their thick epithelial covering.

In some of the papillæ are found loops, or coils, of minute blood vessels; in others there is the ending of a nerve fiber, giving the sense of touch to the tongue; while in other papillæ are minute bodies, the taste buds, especially for the sense of taste.

The Taste Buds. — The **taste buds** are found in the large papillæ at the base of the tongue; and a few are also distributed to other papillæ. They are collections of cells arranged in the form of buds, hence called taste buds. Each bud is not over $\frac{1}{300}$ of an inch in length. The location of these bodies, in the edges of the papillæ, is illustrated in Fig. 96. It is seen that they are situated in the folds between the papillæ, rather than on the upper free surface. Some of the cells composing each bud are directly connected with a nerve fiber, so that whenever anything comes in contact with these cells, an im-

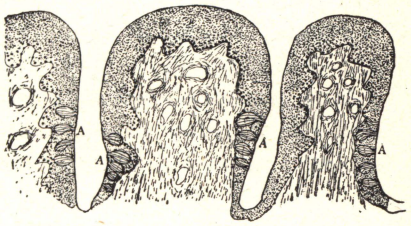

FIG. 96. — A section through two papillæ of the tongue, showing the taste buds A, magnified.

pression of its "taste" is conveyed down the cells and along the nerve fibers to the brain.

The Sense of Taste. — There are four different qualities of taste. We have the sensations which we distinguish as **sweet**, **bitter**, **acid**, and **salt**. In order that any of these may be recognized, the substance must be dissolved. Dry sugar placed on a perfectly dry tongue produces no sensation of sweetness. Some of it must be dissolved before any effect is produced on the cells of the taste buds. The saliva aids in this, and there are also mucous and serous glands in the tongue which secrete a watery fluid. The movements of the tongue promote the flow of these secretions, and thus aid in dissolving the substances and in distributing them over a greater surface. The sense of taste can be greatly improved by practice; it is materially aided by the sense of smell.

Confusion of Taste and Smell. — The senses of smell and taste are often confused. Many times we believe we taste a substance, when it is only the odor which is perceived. It is stated that neither vanilla nor garlic has any distinct taste; it is their odor alone which is noticed. The odor of a drug is often more disagreeable than its taste; for this reason many medicines are best taken after first closing the nose and thus avoiding the odor. A severe cold is said to affect the sense of taste; this is largely because the lining membrane of the nose is inflamed, and we are unable to distinguish odors. In man the sense of taste is more highly developed than that of smell, while in some of the lower animals, the dog for instance, the sense of smell is the more acute.

Habit in choosing Food. — The taste of many substances which were at first very pleasant may become disagreeable because of too frequent use, or of unpleasant associa-

tions; some articles of food are distasteful when first used, but after a time they are greatly desired. Many persons have had to make repeated trials before becoming fond of oysters, tomatoes, or olives; they began by taking small quantities, gradually educating their sense of taste, until a fondness for these foods was acquired. Habit has much to do with this, for we often like and dislike those things which we are in the habit of seeing other members of the family like and dislike.

Impressions of Taste Remain. — If a very sweet or a very bitter substance be placed in the mouth and then removed, the taste is retained for some time. Therefore, if one substance be tasted and then quickly followed by others of different tastes, the impressions will be confused. If the taste of the first was well marked, it may impart its qualities to those following. Therefore, to take a medicine which has a disagreeable odor and taste, first hold in the mouth some strongly flavored substance; then close the nostrils to avoid the odor, and swallow the medicine. In this manner, for reasons already given, there will be little taste of the drug itself. Young persons often form the habit of eating cloves and other spices: this is very harmful, not only because it is likely to injure the sense of taste, but also because it in many cases results in a serious disturbance of the action of the stomach.

Tobacco and Taste. — Tobacco blunts the sense of taste. This is exactly what we should expect; for the papillæ of the tongue become saturated with the tobacco flavor, and the taste buds are impaired by their contact with the poisonous properties of the nicotine. The taste of tobacco is continuously in the mouth, preventing other substances from being tasted unless they are highly

spiced ; this leads to disorders of the stomach as already described.

The Nose. — The sense of smell is located in the nose. The two openings into the nose are called the **nostrils**. At the front they are lined with a number of fine hairs, which aid in keeping foreign bodies from entering the nasal cavities. The framework of the nose consists of bone and cartilage. A thin wall, called the **septum**, divides the interior into two cavities ; these are irregular in shape and extend from the nostrils, in front, to the upper part of the pharynx, behind. The inside of each, or the side toward the median line, is smooth, because the septum itself is smooth ; but the outside is most irregular, owing to the presence of three curved or scroll-like bones, called the **turbinated bones**. These are well shown, as viewed from the side, in Fig. 97. Lining each nasal cavity is a mucous membrane, which is especially thick over the turbinated bones (Fig. 98).

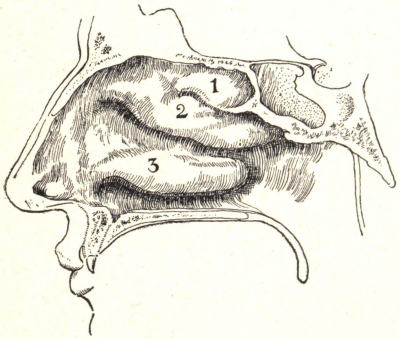

FIG. 97. — The outside of the right nasal cavity, showing the three turbinated bones.

The origin of the odors which we perceive in objects is a very obscure matter, — scientists have several theories about it, but none are fully proved. We know, however, that most substances, probably all substances, have the property which we call odor and that under certain circumstances we perceive it.

Conditions affecting this Sense. — In order to appre-

ciate the odor of a substance, it must be brought to the olfactory nerve (consult Fig. 99) as a gas or vapor. Solid or liquid bodies, in the nose, do not produce any sense of smell. This is easily proved by filling the nose with rose water; after so doing, no odor is perceived from the rose water.

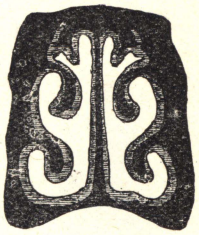

FIG. 98. —Transverse section of the framework of the nose; (1) the nasal cavities. On the outside of each cavity are the curved turbinated bones; (2) the bones forming the roof of the mouth and the floor of the nasal cavities. The black represents the bone, the lighter shade represents the mucous membrane covering the bone.

The continued influence of an odor blunts the acuteness of smell. This is illustrated in everyday life. Upon first entering a room, we may notice the odor of escaping gas, while in a short time we become unconscious of its presence. We notice that a room is "close" only when we first enter it. In all such cases the first impressions should be the guide. Some persons are extremely susceptible to odors of all kinds; they not only quickly detect the unpleasant odors, but they are often made ill by them. In some people the inhalation of certain powders excites violent inflammation of the nasal passages.

The sense of smell may be greatly developed. It is related of a certain boy named James Mitchell, who was born deaf, dumb, and blind, that he could accurately identify many objects, simply by the sense of smell.

Use of Sense of Smell. — The sense of smell is of use in many ways. It aids in the choice of foods, for, as a rule, food that has a tainted odor is unfit for use; and it aids in the detection of impurities in the air. This sense is set on guard over the place where air enters the body, to

give warning of approaching danger. It is true that this sense does not warn us of the injurious agents in the air which cause the contagious diseases, yet it does give notice of offensive vapors which are dangerous to inhale. Vapors which are irritating to the nose would be much more so to the more delicate tissues of the lungs. It is safe to say that in the majority of cases, disagreeable odors mean dangerous odors.

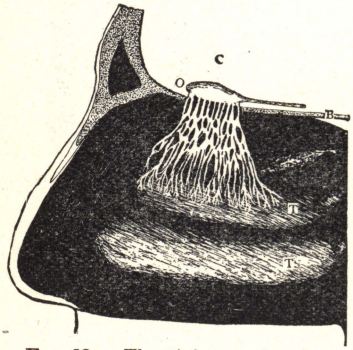

FIG. 99. — The right nasal cavity, showing the termination of the olfactory nerve: T, the turbinated bones, as represented in Fig. 97; O, the olfactory bulb, lying beneath the front part of the cerebrum, C; B, the bony floor on which rests the cerebrum.

Sense of Smell in Animals. — In some of the lower animals, the sense of smell is developed to a marvelous degree. The capabilities of the dog are none the less wonderful because so commonly observed. We all know how he will return home after having been taken away long distances; how he will track his master through crowded streets and in crowded halls; how he will recognize clothing; and how he will follow the trail of the fox for many miles. Other animals, as for example the lion, can tell of the approach of man, or of the nearness of prey; while the deer can detect "in the air" the approach of an enemy when a great distance away.

CHAPTER XXVI

THE SENSE OF HEARING

The Organ of Hearing. — The organ of hearing consists of three parts : the **external ear**, the **middle ear**, and the **internal ear.** The vibrations of the air are collected by the external ear, received by the middle ear, and transmitted through its bones to the inner ear. The inner ear contains the termination of the nerve of hearing, or the **auditory nerve.**

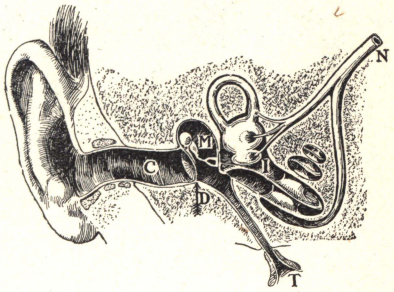

FIG. 100. — The ear: C, the auditory canal, that leads to the middle ear; D, the tympanic membrane at the inner end of the canal; M, the middle ear, or drum, in which are three minute bones; I, the inner ear; N, the auditory nerve going to the brain; T, the Eustachian tube, leading from the middle ear to the upper part of the pharynx.

The External Ear. — The **external ear** consists of a framework of cartilage which is loosely attached to the bones of the head and to the **auditory canal.** The external ear can be slightly moved by the action of certain muscles, although in man this is barely perceptible. In the lower animals, the movements are very extensive, and the ear is quickly changed from one position to another to catch better the sound coming from any quarter.

The auditory canal is about an inch or an inch and a

quarter in length, and extends from the external opening to the middle ear. Near the orifice are a number of fine hairs, and farther in are the openings of glands which secrete the earwax. Both the hairs and wax are for the protection of the ear, keeping out small insects, dust, and other foreign bodies.

The Middle Ear. — The **middle ear**, or **tympanum**, is an irregular shaped cavity about one half an inch in length, and one fourth of an inch from side to side. It is called "the drum of the ear," because it contains air and has a thin membrane over one part of it which is easily affected by wave sounds. The middle ear, or the drum, is separated from the auditory canal by a thin membrane, called the **tympanic membrane**; this is often called the "drum," but incorrectly so, as it is only the thin membrane over the head of the drum; it is elastic, and so thin that it is nearly transparent. A study of Fig. 100 will aid in locating the parts already mentioned. The external ear with the auditory canal, C, is very evident. The middle ear, M, is separated from the outer ear by the tympanic membrane, represented at D. Directly below the letter M are three minute bones, see Fig. 101. A tube extends from the middle ear to the throat. At the right of the middle ear is the inner ear, at I; it is most complicated in its structure, and is separated from the middle ear by a thin membrane against which the stirrup bone rests.

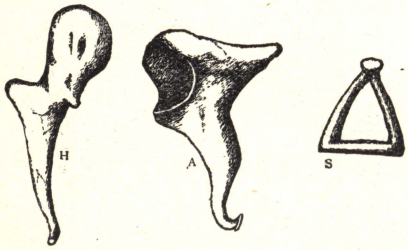

FIG. 101. — The three bones of the middle ear, magnified: H, the hammer, or malleus; A, the anvil, or incus; S, the stirrup, or stapes.

The tympanic membrane is often diseased from inflammation of the middle ear. Not infrequently it has minute openings through it, while sometimes it is nearly all destroyed. It is the function of the tympanic membrane to catch the sounds entering the external ear. As they strike the membrane, they cause it to vibrate, and these excite a corresponding vibration in the parts beyond.

Bones of the Middle Ear. — In the middle ear are three bones, so minute that all together they weigh but a few grains. Yet they give attachment to minute muscles, have movable joints, and perform most important work. From their peculiar shapes they are called the **malleus**, or hammer; the **incus**, or anvil; and the **stapes**, or stirrup. The tympanic membrane is attached to the handle of the hammer; the hammer, to the anvil; and the anvil, to the stirrup; thus a chain of bones is established from the tympanic membrane across the cavity of the middle ear. The outer end of this bony chain is attached to a membrane, and so is the inner end. Beneath the inner membrane, just opposite the stirrup, in the inner ear, is a fluid. Therefore the vibrations of the

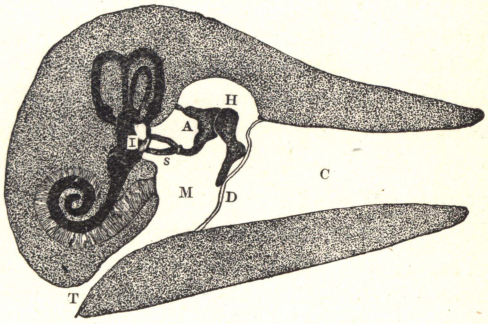

Fig. 102. — The middle and inner ears, from a different view and on a larger scale than Fig. 100. C, the auditory canal of the outer ear; D, the tympanic membrane; M, the middle ear; T, the Eustachian tube; I, the inner ear, surrounded by bone; S, the stapes; A, the incus; H, the malleus.

air at last come to affect this fluid in the inner ear. A reference to Fig. 102 will make this clear: the sound enters the external ear and passes down the auditory canal, C, and strikes against the tympanic membrane, D, throwing it into vibrations; these vibrations are communicated to the handle of the hammer, H; thence to the anvil, A; thence to the stirrup, S; and thence to the membrane to which the stirrup is attached. As this membrane vibrates, it throws the fluid beyond it into corresponding vibrations; and these so affect the endings of the auditory nerve that we have at last the sensation of hearing.

The Eustachian Tube. — The middle ear is not a closed cavity. It communicates with the pharynx by means of a passage, called the **Eustachian tube.** The tube and the middle ear are lined with a mucous membrane, and the former opens into the upper side of the pharynx directly behind the opening of the lower part of the nasal cavity. The object of this tube is to equalize the pressure of the air on each side of the drum membrane. In the healthy ear, therefore, the air in the external ear and that in the middle ear are of the same density, with only a thin vibrating membrane between.

The Eustachian tube is ordinarily closed, opening only during the act of swallowing, and thus allowing the passage of air to the middle ear. As a result of chronic catarrhal affections the tube may not open at all for the passage of air through it. This condition is one of the causes of deafness; but it is often possible to relieve such cases by the use of instruments with which air may be forced through the tube into the middle ear.

The Internal Ear. — The **internal ear** is the most essential part of the organ of hearing, for it contains the

terminal fibers of the auditory nerve. Its parts are deeply seated in the bones of the skull and are most intricate and complicated in structure.

The Sense of Equilibrium. — A certain portion of the internal ear consists of three bony tubes, called the **semicircular canals.** When these canals are injured in the lower animals, it is found that the animal rolls its head from side to side, up and down, apparently unable to direct its movements. A bird thus injured will experience great difficulty in walking to the food placed near, and in picking it up. The animal sees well and appears to hear well, but it reels and falls, acting as if it were dizzy. From these observations and from others made on man, it is believed that the semicircular canals contain nerves which enable the body to maintain its proper poise, or balance, a condition just opposite to that of being dizzy. It is probable that this function residing in the middle ear is connected with the similar function of the cerebellum.

Care of the Ears. — One of the most common causes of injury to the ears is the attempt to remove earwax from the auditory canal by means of pins or other hard substances. The ordinary washing and wiping of the ears with a towel is sufficient to insure perfect cleanliness, while the constant introduction of hard substances is likely to set up an irritation which may eventually impair the hearing. Currents of cold air blowing into the ears may do great harm by chilling the sensitive tympanic membrane. The contact of cold water with this membrane often causes earache, or acute inflammation of the middle ear; for this reason it is always better to place pieces of cotton in the ears before diving, or bathing in the surf.

Foreign bodies in the ear are not always easily removed. Insects are best removed by having warm sweet oil gently poured into the auditory canal; this will either drive the insect out or kill it; in the latter case it can then be easily removed. Physicians should always be consulted for the removal of other foreign bodies.

Hearing and Mental Growth. — We can certainly all appreciate the value of the sense of hearing. We have only to place the hands over the ears for a short time in order to understand how differently all things would seem to us if we were deprived of this sense. We should not only be very careful not to do anything that might impair our hearing, but we should also make every effort to improve it. The mechanism of the ear itself may be in perfect condition, and yet the hearing may be apparently impaired. We say the person is inattentive, does not answer promptly, seems to be indifferent and listless. The center for hearing in the brain may be greatly developed by a little care on our part. Pay sharp attention to what is said to you. Cultivate the ability to reproduce accurately what you hear. Be quick, prompt, alert. These are qualities which will contribute in no small degree to your future success.

CHAPTER XXVII

THE SENSES OF TOUCH; TEMPERATURE; WEIGHT; PRESSURE; COMMON SENSATION; AND PAIN

The Sense of Touch. — A reference to the chapter on the skin will recall the fact that in some of the papillæ of the skin are nerve fibers; in Fig. 73, at (4), is such a nerve termination. These papillæ are called the **touch corpuscles,** as they are especially concerned in the sense of touch. It must be remembered, as shown in Fig. 73, that there is only a thin layer of cells between these corpuscles and the surface of the skin; therefore, it is readily understood that any impression made on the outer surface of the skin is almost in direct contact with one of these touch corpuscles.

The touch corpuscles are very numerous on the palms of the hands and inner surfaces of the fingers, while they are the least numerous on the back. The sense of touch seems most acute on the tip of the tongue. It is the least complicated of any of the senses and is the one first developed in the child. It is in constant use, bringing us into the closest relations with external objects. By its use we learn the size, shape, solidity, smoothness, and many other qualities of bodies.

The sense of touch is capable of being highly developed, especially if great reliance has to be placed upon it, as in the case of blind persons. They soon learn to read by passing the fingers over raised letters; to recog-

nize persons by feeling their faces; to distinguish plants by touching them; and to become expert musicians. The blind sculptor Gonelli is said to have modeled beautifully, relying on the sense of touch alone.

Degrees of Acuteness of Touch. — Those parts are most sensitive to touch which have the greatest number of touch corpuscles. The degrees of delicacy may be measured by means of a pair of compasses with blunted points. The two extended points are touched at the same moment to the skin, while the eyes of the subject are closed; the points are gradually brought nearer together by the operator until the subject feels both points as one, when their distance apart is noted. The same experiment can be performed, though less accurately, with pins. Two pins are held with their points at least an inch apart, and then pressed lightly against the skin on the back of the wrist of another person. Repeat the experiment, bringing the points nearer together each time. Soon the person will declare that he feels but one point instead of two. The distance between the points will give the degree of acuteness of touch for that part of the body. In this way it has been proved that the shortest distance at which the two points of a compass can be distinguished as double is as follows: on the tip of the tongue, $\frac{1}{25}$ of an inch; on the inside of the tips of the fingers, $\frac{1}{5}$ of an inch; on the palm of the hand, about $\frac{1}{3}$ of an inch; on the cheek, about $\frac{3}{4}$ of an inch; and on the back, over 2 inches.

The Sense of Temperature. — The **temperature sense** makes us acquainted with all the variations in the temperature of the skin. If any part of the skin rises above its proper temperature, we feel warm; if it falls below it, we feel cold. When a body which takes heat from the skin is applied to it, a sensation of cold is produced;

while if a body which imparts heat is applied, warmth is experienced. The sense of temperature appears to be principally in the skin, the mouth, the throat, and at the entrance of the nose. The appreciation of temperature varies for the different parts of the body; for instance, hot applications which would be intolerable on the face can be borne when applied to the scalp.

The sensations of heat and cold are sometimes strangely confused. If the hand be dipped in very cold water, and then dipped again in water a number of degrees warmer, there is first a feeling of warmth and then of cold; if one finger be dipped in warm water, the feeling of warmth will not be nearly so great as it would if the whole hand were immersed; if a warm piece of iron is placed in one hand and cold iron of the same weight is placed in the other hand, the cold weight will be declared to be heavier.

The Sense of Weight. — The **muscular sense**, or the sense of weight, informs us of the amount of muscular contraction necessary to lift a body. It depends partly on the sense of pressure and partly on common sensibility. This sense is, therefore, about midway between a special sense and the **common sensation** of the body described below. By placing weights in each hand and then raising and lowering the hands, one becomes conscious of a certain amount of resistance. The muscular exertion required to lift the body gives us the sense of weight; and by practice it is possible to distinguish very slight differences in the weights of bodies, even in those as light as coins.

The Sense of Pressure. — The **sense of pressure** enables us to judge of the amount of weight or pressure, on different parts of the skin. To illustrate this, the hand, or the part being tested, must rest on the table, or must be supported in some way, while different weights are applied.

The subject, who is blindfolded, is not allowed to lift or to move the hand during this test, as in that way the muscular sense would be brought into play too. The various parts of the body differ exceedingly as to the amount of weight required to make itself felt: the most acute portion is the forehead; next, the temples; then the back of the head; and lastly, the forearm.

Common Sensation. — The term **common sensation** refers to all parts of the body, which have sensitive nerves that are capable of causing pleasant or unpleasant sensations. These cannot be compared to the special senses already described; in fact, they are difficult to describe at all. We have many of these common sensations, each one of a character peculiarly its own; thus we speak of the sensations of hunger, of thirst, of pain, of fright, of fatigue, of illness, and of health.

Pain. — If any of the nerves of sensation be disturbed, it produces a sensation called **pain**. If a sensitive nerve be cut in any part of its course, this produces pain which is always referred to the place where the nerve ends, rather than to the point injured. Thus, hitting the ulnar nerve, the "crazy bone," at the elbow causes a pain in the little finger and part of the adjoining finger, as these are the parts in which the nerve terminates. It is not known what causes the differences in the varieties of pain; some are sharp and cutting, while others are dull and throbbing.

Pain is a valuable bodyguard. It tells of the approach of danger, and points to disease when it is present. It may be stated that any so-called stimulus will cause pain, if applied beyond the normal limit and to an excessive degree. Light is the stimulus for vision; yet strong light, as the glare of the sun, is at once painful. Sounds falling on the ear may awake the most pleasant memories;

yet loud and long-continued sounds soon become positively painful. The ordinary contraction of a muscle is free from pain; yet the rapid and violent muscular contractions in spasms are intensely painful.

The nerves of sensation are the great protectors of the body. Without them and their sensitiveness to pain, we should cut, burn, bruise, and otherwise disfigure the body in many ways as we go about our daily work. Pain keeps us from pursuing many harmful courses, and thus aids greatly in protecting the body.

Animals appear to suffer pain, especially those animals which are most noted for their intelligence, such as the dog and the horse. The finer bred the animal, so much the more susceptible is it to pain. The thoroughbred horse appears to suffer great pain through injury and disease, to which the ordinary work horse may be comparatively indifferent. Creatures low in the scale of animal life do not exhibit evidence that they suffer much pain.

CHAPTER XXVIII

CIGARETTE SMOKING

A STUDY of the facts regarding the introduction of tobacco into England and from there all over Europe would take us back to Sir Walter Raleigh's time. When, however, we inquire into the use of cigarettes by boys, we learn with some surprise that previous to the year 1862 cigarettes were rarely used by boys. Their use was first noticed among the students of the Rensselaer Polytechnic Institute at Troy, New York, which was attended by a number of boys from Cuba and South America, who, according to the Spanish custom, smoked cigarettes. They taught the American boys in the institution who were foolish enough to learn. From them the practice spread over the country until now so many boys smoke that there is danger that the American people will become dwarfed in stature and mediocre in intellect, and so lose that splendid mental and physical vigor that has made them what they are to-day. Such a danger is pointed out by the history of the nations where smoking has been universal for a considerable period of time.

Every boy who sings "God Save the King," thrilling with pride at the glorious deeds done to maintain a land of liberty, should remember that no foes without are so dangerous to a country as those foes within that lower the strength and character of its citizens. Such a foe is the cigarette.

Cigarettes are the form in which smoking is usually begun by the young. Evidence of the harm done by cigarettes is too plain to be overlooked. Every few days one sees in the newspapers some such headings as, "Cigarettes drove him Insane"; "Suicide of a Cigarette Smoker"; "Dying from Cigarette Smoking"; "Crazed by Cigarettes"; "Cigarettes killed Him"; "A Cigarette Heart"; "Cigarettes unbalanced his Mind"; "Died from Smoker's Heart"; "Tobacco causes Loss of Memory"; and so on.

The above are the actual titles of clippings collected during a few months from the daily papers. Among the victims of the cigarette thus recorded are: a young American pastor dying at 29 years of age; a 39-year-old superintendent of a savings institution, sudden death; a young mechanic, rendered insane; a 16-year-old boy, insane; a young man of 22, insane; a wealthy retired grocer, sent to an insane asylum; a man of 30, meeting the same fate; a 60-year-old Frenchman, dying of tobacco heart; a young German, same trouble; and so the records go on. Any one who will watch the papers will find material for similar lists.

Boys who have already begun to trifle with their life and destiny by the use of cigarettes may reply to such a list of tragedies that they result from smoking too many cigarettes and that a few will not hurt anybody. The first use of tobacco is the thin edge of the wedge which when once started overcomes resistance.

But the cigarette, or tobacco in any form, is more resistless even than a wedge, for it can overcome the smoker's will to resist. He soon gets where he does not care, because the vigor of his mind and body is weakened by the tobacco. He smokes when he feels like it, regardless

of consequences, and he feels like smoking oftener and oftener, and more and more. It is the nature of tobacco to increase the user's desire for it.

The most marked effects of cigarettes or of tobacco can be seen by the ordinary observer if he is keen and keeps his eyes open, but the slower effects and the strange power which tobacco, like other narcotics, has of making itself craved, are best explained by the physician whose business it is to detect signs of ill health and to understand the action of drugs. Here are some of the things the doctors say about tobacco: —

One who, besides being a physician, is a professor of physiology, teaching in a medical college,[1] tells this of his own personal experience with tobacco, for when a medical student himself he thought he must learn to smoke: —

"I noticed from day to day that during the smoking of the cigar there was a perceptible change of mental attitude toward my work and toward things in general. I would begin a cigar with mind all alert, ambitious to get at some work that needed to be done. After a half hour of watching the smoke curl up toward the ceiling I was conscious of a falling off of mental activity, and unless the work were imperative I usually ended up by taking a half-hour stroll down Michigan Avenue to be entertained by a glimpse of its equipages and its people. I was conscious of a sort of 'don't care' mental attitude toward things in general.

"I have never for a moment doubted that my change in mental attitude was to be attributed solely to the effects of the nicotine. I believe, in the light of subsequent observation, that it is just this effect of the tobacco which

[1] Winfield S. Hall, Ph.D., M.D., Professor of Physiology in the Northwestern University Medical School, Chicago.

makes it especially pleasing to people. If I failed to have my after-dinner cigar, I missed it so much that I woke up to the fact that I was slowly but surely forming a 'drug habit,' and through my medical studies I knew that a drug habit, whether for morphine, cocaine, alcohol, or other narcotic or stimulant, is harmful to the system in direct proportion to its use, and I knew that without exception all of these drugs enslave a person by gradually undermining his will power; the more one takes, the less he is able to stop. When I realized the situation, I stopped."

In America, Dr. T. H. Marble calls attention to the fact that in 1898, during the organization of the volunteer army, it was found that large numbers of young men who were otherwise capable had rendered themselves unfit for service by the use of cigarettes. He states that among the applicants for active service who were addicted to the use of cigarettes the examining physicians found it necessary to reject more men on account of disabilities thus caused than for disabilities arising from any other cause.

An editorial in the *Journal of the American Medical Association* points to a similar condition in France, commenting: "It is said that the increasing mortality in the French army which is stated to be steadily on the increase is largely due to pulmonary affections that are themselves favored by the general habit of cigarette smoking. Other presumable causes are not more active than they were a few years ago, but this one evil seems to be constantly gaining ground, and is therefore held as mainly responsible for the increasing mortality from lung disorders in the French army. . . . The practice [of cigarette smoking] was originally a Spanish one, and it suggests a query

whether the misfortunes of the Spanish nation may not be due in part to a race degeneracy thus produced. If so, it will be well for us and other nations to take warning from their example. In these days, also, when wars are still in fashion, whatever can diminish the military strength of a people is a national calamity."

The growth of the cigarette habit in Canada is shown by the consumption for five years as follows :—

1904	211,302,041	1907	355,170,280
1905	250,860,387	1908	384,809,374
1906	269,334,839		

And a very considerable proportion of this cigarette consumption is due to the prevalence of cigarette smoking among youths.

Dr. A. C. H. Friedman says: "While the dangerous effects of tobacco poisoning are known to affect almost every part of the human organism, the result which brings the patient quickest to the physician is the injury which it causes in the eye. . . . The most characteristic symptoms of chronic tobacco poisoning are evidenced in the eye, and they are all known under the name of 'tobacco amblyopia.' The time necessary for the development of this disease is individually different and ranges from six months to many years."

Dr. Osler describes three groups of cases of the so-called tobacco heart: First, the irritable heart of smokers, seen particularly in young lads, in which the symptoms are palpitation, irregularity and rapid action; secondly, heart pain of a sharp, shooting character, and thirdly, attacks of much greater severity.

Many boys begin the use of tobacco before they are old enough to know or understand the harm it does. They are not qualified to judge of its effects upon those they see using it. They seem to be a good deal like sheep; there is an old saying that if one sheep of a flock goes over a stone wall, the

rest are sure to follow. Especially are boys given to doing what they see men do. They do not stop to think whether they are imitating a man's virtues or his vices.

Tobacco owes its activity and poisonous properties to a volatile oil substance called nicotine, which exists in different proportions in different specimens of the leaves, ranging from two to eight per cent. A large dose of tobacco, or even a small one to those unaccustomed to it, produces very decided symptoms. It causes nausea, giddiness, vomiting, great prostration, frequent and very feeble pulse, cold, clammy skin and trembling of the limbs. Convulsions sometimes occur.

Sir Lauder Brunton states that if nicotine is pushed to too great an extent it is a powerful cardiac poison and has a curious effect upon the heart. He also states that in the lower classes of hospital patients there is frequently found an affection of the heart characterized by extraordinary irregularity, but amongst the upper classes, who smoke better tobacco, the result of over-smoking is more frequently shown in sudden faintness. The man falls as if he were shot.

Every well-informed boy knows that tobacco is forbidden to men who are training for games and races. The reason is that tests and experience have shown that tobacco weakens the muscles and makes one incapable of doing his best. This fact is coming to be well known by business firms who employ men and boys, and it is closing many desirable positions to those who use tobacco.

The effect of tobacco upon efficiency is the same whether a man is working for himself or for others.

When a business man advertises for a boy, he looks over the applicants that come, and no recommendation that a boy can bring will offset the tell-tale marks of tobacco stains on his fingers. The business man has learned by experience that the boy who smokes is likely to shirk his duty when no one is watching; his trustworthiness cannot be relied upon.

The qualities which the employer looks for in the boy he selects are the ones that are most essential to the boy's own success if he is struggling independently to win the best prizes in life. In whatever way he works, tobacco holds him back.

Dr. E. Stuver, President of the Wyoming Scientific College, states that in his observation and experience the use of tobacco has a peculiarly demoralizing effect on the moral nature of the young. He says further: "In addition to making boys tired, stupid, and lazy, it makes them irritable, perverse, and careless of the rights and feelings of others, besides in many instances leading to lying and even stealing. This tendency to moral degradation is exceedingly prevalent among habitués of all kinds of narcotic poisons."

Another physician, Dr. Matthew Woods, of Philadelphia, adds the following to the list of the bad effects of tobacco upon the brain: He says it weakens the power of achievement, soothes the excited nerves only to render them ultimately more irritable, weakens self-restraint and will power, perverts the taste, diminishes mental capacity, corrupts the moral sense, stimulates the animal nature, causes inferior scholarship in students, and takes away the sense of shame in failure. He finds that it "banishes that beneficent discontent which is the originator of reform, the maker of beauty; without it we retrograde, with it we advance. Discontent is a progress-provoking quality. It was discontent that invented the spade, the harrow, the plow. It created the locomotive, replaced the galleon by the steamer, the postilion by the telephone. The studiousness of the scholar, ardor of the poet, sacrifice of the patriot, fire of the hero, and the rapture of the saint are all due to the presence of rest-preventing discontent;

and yet so oblivious are we of its value as a means of conquest and development, that instead of having it instigate to the removal of obstacles, like our elders, we merely aim to destroy it with a drug; we put an enemy in our mouths to steal it away, and thousands of young men as a consequence, under the spell of its artificially induced calm, fail in the race of life as the great world with its struggles and aspirations moves on."

There is no class of people who see more clearly than the educators of the country the bad effects of tobacco upon the young. The testimony of an experienced school principal, Professor H. H. Seerley, of the Iowa State Normal School, clearly expresses what every observant teacher can corroborate. He writes: "After making a study of several hundred boys, running through a period of ten years, I give only observed facts, and neither assume the conditions nor jump at foreordained conclusions.

"1. Boys that begin the habit at an early age are stunted physically and never arrive at normal bodily development.

"2. Accompanied with the use of the narcotic were certain disordered physical functions, such as indigestion, impaired taste, defective eyesight, dulled hearing, nervous affections, and diseases of the heart. I have not found a single case of early addiction to the habit of tobacco using that did not suffer with one or more of these direful abnormal conditions.

"3. Tobacco, used in any form, destroyed the ability of a pupil to apply himself to study, and prevented his comprehending or remembering his lessons. The mental faculties of a boy under the influence of the narcotic seem to be in a stupor, and since depraved nerve power stultifies and weakens the will power, there is but little use

for the teacher to seek to arouse the dormant, paralyzed energies or to interest and foster the fagged desire. I have not met a pupil that is addicted to the habit who will go through a single day's work and have good lessons. I have not had one whose scholarship record was good, and in almost every case the deportment was below the average standard. At the regular examinations for promotion, nearly every one of the tobacco-using pupils fail in doing the most reasonable test work, even if this is not the first time the work has been passed over in class. I have had numbers of cases in which they have remained in the same grade for four successive years, and then they were not ready to be advanced into the next higher class."

CHAPTER XXIX

SOME ESSENTIALS OF HEALTH

The Control of our Bodies. — Our study in the preceding pages of the elementary truths of physiology has not been complete unless we have observed that the first purpose there has been to explain the working of our bodies and the laws of health governing them; and the second purpose, to show that it is only by the use of discretion and the exercise of our will power that we can keep our bodies and minds in the best possible condition.

What every boy and girl should aim to do is to put his body under the control of his mind in matters relating to his own health. That is to say, he should so apply his understanding of the uses of the various organs of the human body and the effects of this or that treatment upon them, that he is able for the most part to avoid those things which will be harmful to his health and cultivate those things which will help to upbuild his physical and mental manhood. For physical manhood is the foundation upon which mental and moral manhood must rest. Control of our own bodies, then, based upon a proper understanding of them, is the first step toward the attaining of true manhood or womanhood.

We have seen that the brain is the seat of the mind, and though we may not understand all the physical operations of this wonderful organ, we do know that by means of its agents, the nerves, which connect it with all parts of the body, it largely controls our voluntary

muscles and therefore our actions. We must will to do a thing before we can do it. Thus we see how important it is for us to keep the brain in a healthy state, for this means keeping the mind clear and active for its work of controlling the body.

The Deceptions of Alcohol. — We have already noted that alcohol taken into the body, while it is capable of affecting almost every important organ, produces its quickest and most disastrous effects upon the brain and the nerves. We saw how its first effect is that of a quickening of the circulation in the brain, giving the one who uses it a feeling of exhilaration which he is apt to mistake for a real increase of mental power.

As a matter of fact the effect of alcohol upon the whole system is in the beginning a series of dangerous deceptions. With the quickened action of the heart and the rush of blood to all parts of the body, a feeling of strength is given, when in reality the individual is made weaker. A sense of intellectual power is felt for the moment, when the mind is actually being clouded and dulled. A feeling of warmth is imparted, when the blood is in reality being rapidly cooled. A feeling of power over himself and others deceives the individual, for he is really less able either to control himself and his own lower appetites or to resist temptations offered by others. As more and more alcohol is taken into the system, the brain is affected more and more, and the control of the mind over the body becomes less and less effective. Evidences of this are seen in the individual's speech which becomes rambling and loose because of his inability with his impaired brain to think clearly and consecutively ; and in the loss of the control of the mind over the muscles of the body, to such an extent that he can neither stand nor walk steadily.

If when the individual reaches this state he takes still more of the poisonous liquid, he finally loses all consciousness and consequently all control over his movements. Thus he, for the time being, is as far removed as possible from the first step toward the attainment of true manhood, — the mastery of his own body. Such a condition is, of course, only reached by the use of large quantities of liquor at any one time.

Small Quantities impair Control. — But what effect have alcoholic liquors when used in smaller quantities upon the ability of the mind to control the body? It is a physiological fact, as has been pointed out, that the continued use of alcoholic drinks, even in small quantities, impairs the delicate brain cells and therefore to that extent weakens the supremacy of the mind over its servant, the body. It is not sufficient to point to this or that "moderate drinker" who has achieved conspicuous success in life, for what is there to show but that his success might have been greater had he kept his brain free from all influences of this poison. Moreover there is abundant testimony of habitual but so-called moderate drinkers to the effect that their usefulness has been impaired and their mental powers weakened by the constant use of alcoholic beverages.

Dangers of the Social Glass. — And what of the man who uses alcohol neither in large quantities, nor habitually in small quantities, but who takes a glass occasionally for the sake of good fellowship or under pressing invitation? The danger in such cases, of course, arises from another cause. It must always be borne in mind that there is in the nature of this narcotic the power to create a demand for itself in the system, the power to create an appetite for itself that insists upon being gratified. The real peril to the man who takes a single drink is that he is trifling

with a substance which has the power to fasten a fatal appetite for itself upon him.

To the "moderate" drinker also there is ever present the danger that he may sooner or later lose control of his will power and drink more than he intends. For as we have already noted, the man who takes one or a few drinks may be so mentally weakened, that he is less and less able to exert his self-control to resist the impulse to drink more. He becomes more and more careless and reckless, less and less considerate of consequences. We are not going too far, therefore, when we make the broad assertion that the use of alcoholic drinks is always likely to result in an impairment of the operations of the brain and a consequent loss of control over the body. The man who uses them, therefore, does so at the tremendous risk of debasing his own manhood.

The Strengthening of Character. — But there is another side to this serious question. Not only is the man who takes a firm stand against all use of alcohol in any form and in any quantity free from the danger of finding himself unable to exercise his usual self-control, but he is actually strengthened in character each time by his refusal. After a time the refusal becomes less difficult to make and to stand by, and he comes to a fuller realization of his own ability to do what he knows is for his own physical and mental health and happiness.

There are many historical instances of men of genius whose promising careers have been cut short and whose lives have been utterly ruined by the loss through strong drink of this one power of mind, — the power of self-control. And there are many more instances in which men of great minds have achieved continued success in life by their firm refusal to indulge an appetite which they real-

ized could lead only to their physical and mental undoing. Thus when the old Trojan hero Hector, on being overcome at saying farewell to his loved ones, was offered wine by his mother, he said to her, " O venerable mother, bring me no caressing wine to unnerve me and make me forget courage and strength."

Tobacco dulls Ambition. — What has been said of the cultivation of our powers of self-control in abstaining from the use of any form of distilled or fermented liquors may be said also of the use of tobacco. Of course the injurious effects of tobacco upon the system are not so destructive as those of alcohol. But we have seen in previous chapters that tobacco has, though in a less degree, the same effect upon the heart, causing the blood to flow more quickly and resulting in a slight rush of blood to the brain. There follows a dulling and soothing effect upon the mind, which robs it of ambition and energy and gives a feeling of contentment and self-satisfaction where there should be a feeling of eager unrest and the strong desire to accomplish something. It has been demonstrated beyond question that the continued use of tobacco by the young weakens the mental powers of the individual by its effect upon the brain. It gives an artificial peace of mind in place of a pressing desire and a strong will to achieve success. To just the extent that one's will power is weakened by the use of this narcotic will his power and control over his own body be impaired.

The Weakening of Mental Force. — And this is entirely aside from its many other injurious effects upon the system, — effects upon the digestion, the heart, the lungs, the nerves, the eyes. Therefore, as in the case of alcohol, though in less degree, we may say that the boy or the man who uses tobacco becomes through the impairment of his

mental forces less and less the complete master of his own body. Especially is this true in the case of the boy who uses it. His mind is then in the process of development and is in consequence more easily affected. As illustrated in Chapter XXVIII, instances are all too frequent in which boys addicted to the habit have become incapable of clear thinking, have largely lost their memory, and have had their will power so seriously weakened that they are unable to stand for things that are right against things that they know to be wrong. Indeed, not a few cases could be given in which the use of cigarettes has led to the complete loss of the reason.

All this teaches us that if we are to maintain the proper supremacy of the mind in its mysterious relation of control over the body, and thus develop our physical and mental manhood, we must carefully avoid those things which tend even in a slight degree to clog the operations of the brain and to destroy our self-control.

Habits of Health. — We have already noted that habits are formed by the frequent repetition of the same act. When we see an object or hear a sound for the first time, our attention is attracted to it by reason of its novelty. But if we pass the object or hear the sound every day, it soon ceases to make any impression upon us. And so it is with those of our actions which become habits. By constant repetition they become so much a part of us that we sometimes speak of our strong habits as being "second nature" with us.

Perhaps the most important thing for the boy and the girl, who in a few years will be the man and the woman, is the formation of what we may call habits of health — that is, habits of doing those things which will upbuild and strengthen the body and keep it in healthy condition,

and habits of refraining from the things which will impair and weaken the body and interfere with the operation of the laws of health.

Habits of Imitation. — We all know that a very young child learns by imitating those about him many of the daily acts which soon grow to be habits, requiring little or no thought. He learns to talk by imitating the sounds his elders make in speaking. He learns to walk, to play, to sing, in much the same way. Indeed, almost all of his earlier acts are imitative, and those about him are constantly surprised by this or that thing that he "picks up" from observation of older people. Even in later life many of our acts are imitative, and, therefore, many of our habits are formed by copying those with whom we come in contact. But when we have grown old enough to distinguish between good habits and bad habits, between healthful habits and habits injurious to health, it becomes our duty to imitate only those acts which we know to be helpful or at least harmless, and to refrain from imitating those which we know to be hurtful to our bodies or our minds.

The Forming of Narcotic Habits. — Many a young man takes his first drink and many a boy smokes his first cigarette because he sees those about him, perhaps his elders, doing the same thing, and he thinks it manly and big to do what others are doing. In fact there is often a little zest added to the act because he knows that he is treading on dangerous ground. He does not stop to consider what he has learned about the effect of these things upon his body and mind. He feels so strong and well that it seems absurd to be casting about for possible results in the future. He does not stop to think that ninety-nine out of a hundred of those physically and mentally wrecked by the use of

these narcotics made their beginning in just this same way, with the same belief in their power not to form the habit and not to yield to it.

But the appetite is aroused, and the habit begins slowly to twine itself about him. It requires an effort of the will to break away from any habit, because it is much easier to do what we are accustomed to do than to follow a new course of action. Especially is this true in the case of the tobacco and drink habits, for not only may a consuming appetite for these things be created by their use but, as we have seen, the will power itself is likely to be steadily weakened and broken down. Many a prisoner in the chains which these habits forge about their victims declares himself powerless to shake off the bands which have bound him, in spite of his honest desire to do so.

Perhaps the most serious effect of narcotic habits is upon the moral nature of their victim. The man who uses alcoholic drinks tends to lose his finer sensibilities and to become more and more degraded in thought and action. In appearance and in conduct the drinker too often becomes less and less like the noble being for whom he was intended, and more and more like the brute. A visit to any of the criminal courts of our large cities will convince us of the large percentage of crime committed by those who have reached the depths of moral degradation through the use of strong drink.

In regard to tobacco it has been proved that its use by boys often results in a dulling of the moral sense until they are scarcely able to distinguish between right and wrong. Our many reformatories for the cure of youthful unfortunates who have been morally deranged by smoking offer abundant evidence of this fact, which cannot be argued away.

Ignorance or Indifference. — In one way or another all of us are beset with certain physical desires and appetites, but these desires and appetites vary with the individual, all the way from a mere inclination to an almost overmastering passion. Moreover, we vary greatly in strength of intellect and will, and in ability to resist and control our physical appetites. Also we inherit much that plays an important part in the mental and physical conditions under which we are to work out our lives. But in spite of the drawbacks with which many a young man starts life, — whether they be drawbacks due to inheritance, or to appetite, or to weakness, or to his surrounding conditions, — it may be said in general that the formation of such harmful habits as have been pointed out, and the failure to acquire in youth habits of health, are due either to (1) ignorance of consequences, or (2) indifference to them.

We always feel greater pity for him who goes wrong from ignorance than for him who does so wilfully. If from either ignorance or perversity we violate the laws of nature which govern our bodies, we are certain to suffer for such violation. Ignorance as to the consequences which come to the physical, mental, and moral nature from the taking of alcohol and tobacco into the system no longer prevails. Men who yield to these habits do so knowing what the results may be. Since the laws of hygiene and physiology, as well as observation of those who use alcoholic drinks and tobacco, show the terrible mental and moral degradation in which these habits so frequently result, it seems almost incredible that any one should be indifferent to the dangers of forming such habits. This indifference is but an indication of lack of moral strength. One who knows the right and pursues the wrong through indifference is not master of himself. Indifference to

one's own well-being will eventually bring indifference to one's duties in the business and social world. The young man who is so indifferent to the laws of health as to indulge in alcoholic drinks and cigarette smoking finds limited opportunities for employment, for the first question of an employer usually relates to a man's habits.

Importance of forming Helpful Habits. — The majority of the habits which are formed for life fasten themselves upon us in boyhood and girlhood or in early manhood or womanhood. These are the times in our lives, therefore, when we should be most careful. But it is not sufficient simply to avoid the formation of injurious habits; we must also seek to attach to ourselves those habits which we know will best promote our physical and mental prosperity.

We must cultivate habits of cleanliness, habits of temperance and regularity in our eating and drinking, habits of proper respiration, habits of musular and mental exercise, habits of rest and sleep. The necessity to the human body of all of these things has been pointed out elsewhere. What we want to emphasize here particularly is that by forming these habits of health in youth they become so much a part of our everyday life that it is only by an effort of the will or by some unavoidable circumstance that we depart from them and incur the danger of illness. Our bodies are thus made and kept the strong and healthy servants of our minds.

What is Success? — Every right-minded boy and girl who stops seriously to consider the life upon which he is starting out desires to make a success of that life. But it will be found that people vary very widely in their ideas of what success is. It is a much too common notion that success in life means the amassing of a fortune or the attainment of some high position among our fellow-men where we can be constantly in the public eye.

As a matter of fact neither of these things is to be despised, but it is certainly true also that neither of them is a real test of any man's success in life. It is neither possible nor desirable that all of us should become millionaires, nor that all of us should become famous men. For most of us the sphere of our reputation and influence must be comparatively small — indeed, in many cases must be largely restricted to the community in which we live.

What, then, should be the success toward which each of us ought to labor? On this point the president of one of our great American universities has this to say: "In every walk of life, strength comes from effort. It is a habit of self-denial which gives the advantage to the man we call self-made. He is often very poorly put together. His education is incomplete; his manners may be uncouth. His prejudices are often strong. He may worship himself and his own oddities. But if he is successful in any walk in life, he has learned to resist. He has learned the value of money, and he has learned how to refuse to spend it. He has learned the value of time, and how to convert it into money, and he has learned how to resist all temptation to throw either money or time away. He has learned to say 'No.' To say 'No' at the right time, and then to stand by it, is the first element of success."

The First Element of Success. — Of course there are many elements which go to make up the character of the successful man. But the ability to say "No" is the first and most important of them all. And since the enjoyment of a sound mind in a healthy body is absolutely necessary to the development of our powers, we must learn above all things to say "No" to those things which we know to be injurious to our bodies and our minds. Surely it is unnecessary for us again to point out that one of the most

injurious and dangerous of all the vices against which our civilization has to battle is the use of the narcotics, alcohol and tobacco, which take such firm hold upon many of those about us.

The Habit of Work. — Next to a clear brain and a strong body the thing most needed to win success is the willingness to work. Every boy and girl should guard against the formation of careless and shiftless habits and indulgence in laziness. We appreciate most the things we work hardest to win. Indeed, we may say that no success in life is achieved without work. This does not mean that if we work, we shall always accomplish our desire, always attain our goal. But it does mean that in spite of our occasional failures we shall make ourselves useful to those about us, and the world a little better for our having lived in it. And that is real success in life.

The reward of right choice is good health and success in life; the result of wrong choice is ill health and failure. Real success cannot be attained without constant self-mastery, but that goal abundantly justifies the effort to reach it.

Choice of Good Habits in Youth. — Each year that passes over a youth will open up before him new and dangerous temptations. As he grows older he will be thrown more and more upon himself and will be called upon, in business and elsewhere, more and more frequently to make a choice between the right and the wrong. With a knowledge of the physiological truths that relate to his own body, it behooves him in his youthful days, when his character is forming, to cultivate habits which will add to his physical, mental, and moral well-being, to shun entirely those things which will lead to the formation of pernicious habits.

CHAPTER XXX

EMERGENCIES

In cases of emergency it is necessary to act promptly and properly, the first requisite being presence of mind. Remember how necessary it is that the body should at all times be supplied with an abundance of pure air. Keep in mind also that tight clothing about the waist or neck may interfere with respiration, even when there is plenty of fresh air for the sick person to breathe. In all cases of sudden illness, bystanders should be kept at a distance. It is not the time to indulge in curiosity. All who are not needed will show good sense by stepping away.

If there is vomiting, turn the person on his side, with the head bent down a little, in order to prevent choking. There is a popular notion that the first thing an injured person needs is an alcoholic stimulant. To act upon this idea is both incorrect and dangerous. Let the question of giving drugs rest with the surgeon.

Bites from Animals. — When one has been bitten by any animal, the wound should be promptly and thoroughly cleansed. It is better to consult a physician about wounds made by animals, as they may be serious.

Bleeding. — When the skin is broken by either a cut or a bruise, blood comes quickly to the surface. If the wound is not serious, the flow of blood will slacken, and

gradually stop. Before treating any wound the hands of the operator should be thoroughly washed, and everything brought in contact with the wound should be very clean. Bathe the wound with the purest water obtainable. The object of bathing these slight wounds is to remove all foreign substances and to make the wound as free as possible from germs. If the wound is not serious, it is only necessary to cleanse it with water, and then bring the edges of the wound into their natural position by means of strips of adhesive plaster, over which should be placed a bandage made from some clean cloth.

Often, however, bleeding from a wound may be so severe that the first object must be to check the flow of blood. Remember that bleeding can usually be checked by elevating the wounded part above the level of the heart. To illustrate: If the finger has been cut, do not allow the arm to hang down by the side, but hold the hand up as high or higher than the level of the heart. Directly over the wound apply a firm compress of the best and cleanest material at hand.

Ordinary wounds heal quickly, if they are free from all foreign matter and are made absolutely clean at the start. A great many antiseptic washes may be recommended, but for all ordinary purposes pure water is sufficient. Water which has been boiled and then cooled is the best. Carbolic acid is often recommended and used, but it is a strong poison, and should not be kept about the house.

The remarkable success of the Japanese surgeons in their treatment of wounds during the war between Russia and Japan has taught us anew that perfect cleanliness is the great secret in the treatment of wounds. Everything that comes in contact with a wound in any way should be perfectly clean.

FROM AN ARTERY. — Most of the arteries lie deep in the body, and consequently they are not frequently wounded. When an artery is cut, the blood will flow in spurts or jets, and the color of the blood will be a bright red. As a rule, nearly every wound of an artery is of sufficient importance to require the immediate attention of a surgeon. Until the surgeon arrives there are three things to do: (1) have the person lie down; (2) elevate or hold up the wounded part if possible; (3) press on or near the wound with the fingers until a **compress** or firm bandage can be provided. It is better to apply the compress a very short distance from the wound, and on that side of the wound *toward* the heart. This leaves the wound free to be properly cleansed and bound up.

FROM THE CAPILLARIES. — When the capillaries are injured, blood simply oozes from the surface. The blood that comes when the skin has been scraped, is an illustration of capillary hemorrhage. The treatment is usually very simple. Often mere exposure to the air will check the flow. Water, either very hot or very cold, may be applied if necessary. Placing a pad or compress directly over the wound will also check the blood.

FROM A VEIN. — From an injured vein the flow of blood is steady and not in spurts. The treatment is the same as that for bleeding from an artery, except that the pressure should be on the side *away from* the heart.

FROM THE LOWER EXTREMITY. — A person who has been wounded in the leg should lie on his back with the wounded leg held up, or the leg may be supported on a high box or step, as illustrated in Fig. 103. If the injury is in the foot, and the bleeding continues after the leg is raised, apply a bandage, beginning to wind it at the toes, and continuing it a short distance past the wound.

FROM THE UPPER EXTREMITY. — When hemorrhage occurs from the hand or forearm, the arm should be raised above the head. If the bleeding continues, a compress should be applied over the brachial artery. Employ the bandage and the stick in the same manner as recommended for the femoral artery. Sometimes it is useful to place a compress in the armpit, and bind the arm down to the side, thereby making firm pressure upon the axillary artery, as shown in Fig. 105.

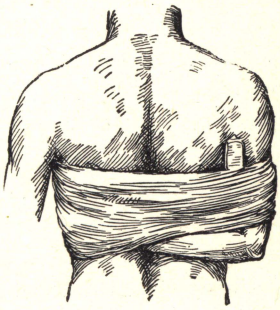

FIG. 105. — Pressure upon the large vessels in the armpit by a compress.

FROM THE HEAD. — Make pressure with the fingers directly down upon the bone on the side of the wound *nearest* the heart, if an artery is injured; and on the side *away from* the heart, if a vein is injured. Make a small pad and place it directly over the wound, holding it in position with a bandage passed snugly around the head.

If an artery of the face is injured, place pressure upon the artery where it crosses the lower jaw, which is about one inch in front of the angle of the jaw.

FROM THE LUNGS. — In a case of hemorrhage from the lungs, call a physician at once. Have the person lie down with his head and shoulders raised. He may be given half a glass of cold water in which has been dissolved a teaspoonful of salt.

FROM THE NOSE. — Bleeding from the nose will generally check itself, if the person remains quiet for a short time in the sitting posture. Cold water may be applied to the forehead and over the nose, or to the back of the

neck. Or, press the nostrils together for a few moments, breathing through the mouth. Or, place the hands and feet in water as hot as can be borne. Do not blow the clots from the nose, but allow them to remain a few hours until all danger of renewed bleeding has passed. If bleeding still continues after these remedies have been tried, a physician should be called.

Bruises. — Bruises are commonly called black-and-blue spots. If the bruise is slight, cloths wet in cold water should be placed over it. If severe, hot water and hot poultices are better. Sometimes bruises are fatal, even when there is no break in the skin; the injury may be sufficient to produce serious damage to internal organs. Severe bruises demand the prompt attention of a surgeon.

Burns. — In a case of burning, if the burned part is covered with cloth, great care must be used in removing this cloth so as not to pull off any of the skin. If the cloth adheres firmly, allow it to remain, cutting away all unattached portions. Where there are **blisters**, open them with a new and perfectly clean needle, and gently press out the water. If the burn is slight, cover the parts with cloths wet with water in which has been dissolved as much baking soda as the water will take up, and change these cloths frequently. When the burn is more severe, saturate the cloths with a mixture composed of equal parts of sweet oil and lime water. If these lotions are not at hand, an application of cream or ordinary machine oil will give partial relief. Cover the injured part with gauze, soft cotton cloth, or other light material.

If a person's clothing is on fire, he should lie down quickly and roll over and over on the floor. Under no circumstances should he remain in an upright position, as the flames tend to rise and surround the face, thus causing

great disfigurement or fatal choking. If a coat, rug, or blanket is at hand, this may be quickly thrown about the body before rolling upon the floor. If another person is present, he should throw the nearest available wrap over the burning parts; and he should not hesitate to throw the injured person down forcibly, if necessary, as the danger is immensely increased by standing or running. In approaching a person whose clothing is burning, it is wise to hold a rug, blanket, or coat before one's body as a protection.

Sunburn is the same as any other burn, only it is of slight degree. The treatment consists in applying the soda solution or in covering the parts with unsalted butter or vaseline.

Convulsions. — Small children and babies occasionally have convulsions or fits because of some irritation in the alimentary canal, and also from other causes. As soon as the convulsion occurs, the child should be quickly placed in water as hot as can be borne. The hot bath will usually stop the convulsion at once. The child should be kept in the bath for several minutes, and then should be thoroughly dried, warmly covered, and placed in bed. If another convulsion occurs, the same treatment should be repeated. A physician should always be called.

Dislocations. — If there is any reason to believe that a joint has been dislocated, the injured parts should be kept perfectly quiet until the surgeon arrives. Do not handle the joint, as serious damage may be done in that way.

Drowning. — If the heart still beats when the person is removed from the water, there is a possibility of saving his life. As the beating may be so faint that it cannot easily be discerned, it is always best to assume that the

heart still beats, and to begin with **artificial breathing** at once. As soon as the person is taken from the water,

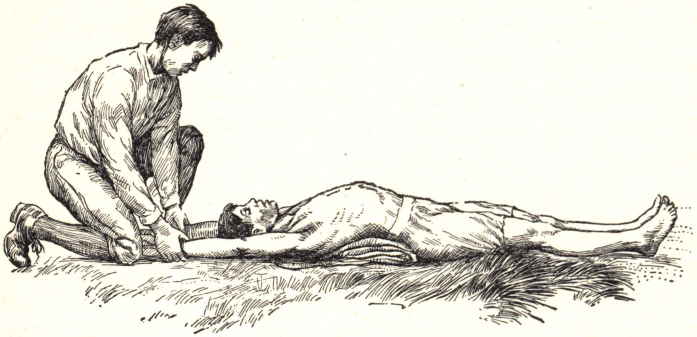

FIG. 106. — First position in artificial respiration — inspiration.

lay the body face downward. Put your arms about the waist and partially raise the body, moving it quickly up

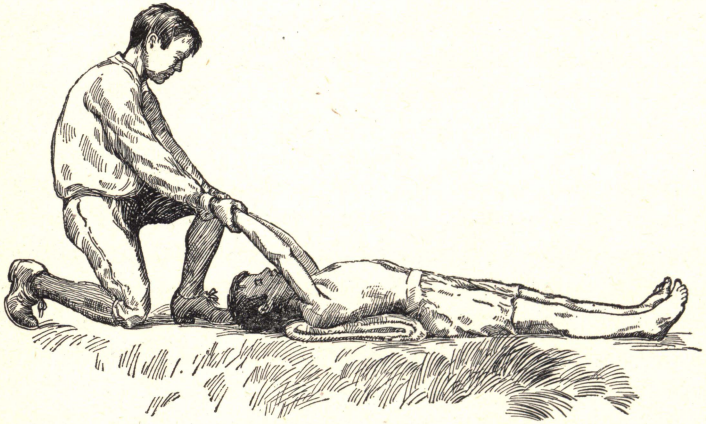

FIG. 107. — Beginning the movement of expiration.

and down a few times ; this allows the water to run out of the mouth and throat. This should not occupy longer

than a part of a minute. Then proceed with artificial respiration (Figs. 106, 107, 108), as follows : —

Place the person on his back with a roll of cloth under the shoulders. Kneel at his head, and grasp his arms at the wrists. Draw them slowly over the head, and hold them there long enough to count four deliberately. This raises the chest walls, and allows the air to rush into the enlarged thoracic cavity. Then push the arms down again, firmly but gently against the chest, holding them in that position long enough to count four as before. This movement

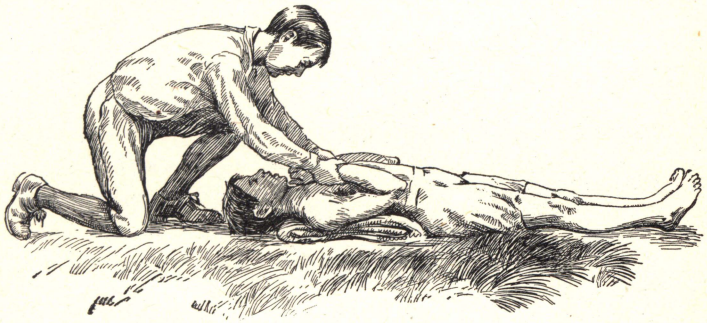

FIG. 108. — Final position in artificial respiration — expiration.

diminishes the size of the thoracic cavity, and pushes out the air. The case should not be abandoned until the artificial respiration has been tried for at least two hours. The tongue generally falls back into the throat, and prevents the passage of air into the lungs. To remedy this, have an assistant grasp the tongue with a dry handkerchief and draw it out of the mouth.

Fainting. — The principal thing to remember in cases of fainting is that there is not enough blood in the brain. Therefore those things should be done that will promote the flow of blood to the head. Usually all that is neces-

sary is to place the person on his back and keep the head low, certainly as low as the body; do not raise his head until consciousness has returned. Never give alcohol or any alcoholic liquor. Dashing a little cold water in the face may give aid. If a person feels faint in a public place where it is difficult to get to the air, the faintness may be remedied by leaning the body forward for a few minutes, with the head between the knees.

Foreign Bodies in the Ear. — When an insect is in the ear, it will often leave if a bright light is placed a few inches from the opening. If this fails, the ear may be gently syringed with warm water, or a few drops of warm sweet oil may be poured in. If the foreign body is anything which might swell, a bean, for instance, no water should be used. Any small particle may fall out if the head is turned on the side with the affected ear down, especially if the head is shaken. In case this experiment fails, the removal of the substance should be left to a surgeon.

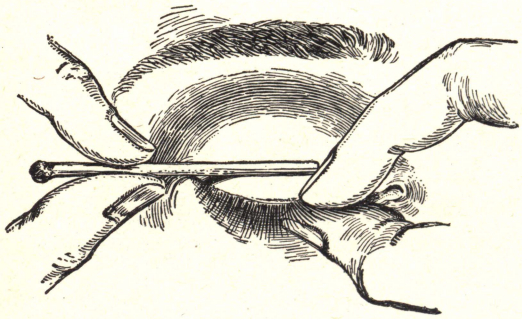

FIG. 109. — Illustrating the first steps for the removal of a foreign body from the inner surface of the upper lid. The eye is closed; the match is in position; the eyelashes are grasped; and now the lid may be turned over the match, thus exposing its inner surface.

Foreign Bodies in the Eye. — To remove foreign bodies from the eye, close the eye and allow the tears to accumulate. When the eye is opened, the extra flow of tears will

often wash out the foreign substance. If the substance seems to be beneath the lower lid, let some one take hold of the lower eyelashes and pull the lid down while the patient looks up. In this way the inner surface of the lower lid is exposed, and the particle can be gently removed with the corner of a handkerchief. If it is beneath the upper lid, its removal is generally more difficult. By grasping the upper eyelashes the lid may be pulled down over the under one, and frequently the body may thus be removed. If this fails, the upper lid may be turned and its inner surface examined. To do this have the person look down ; then with some small article, as a match, press upon the middle of the lid, at the same time grasping the upper eyelashes and turning the lid up and over the match. This method is illustrated in Figs. 109 and 110. If a foreign body is on the exposed surface, it can be easily seen and removed. If the particle is embedded in the substance of the eyeball itself, a surgeon should remove it. It is unwise to rub the eye when any foreign body is in it, as this may embed the particle more deeply in the tissues. After the removal of a foreign body, a sensation as if it were present often remains for several hours.

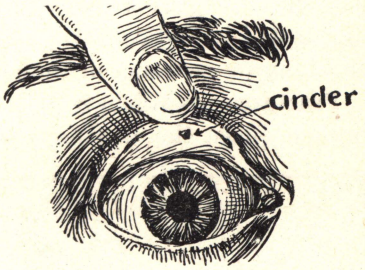

FIG. 110. — Showing the upper lid, turned, with a cinder on the exposed surface. While the finger holds the lid, turned, the cinder is removed by gently wiping the lid with a clean handkerchief.

Foreign Bodies in the Nose. — To remove foreign bodies from the nose, try closing the clear side of the nose and blowing forcibly through the other. If this fails, sneezing

can be excited by tickling the nose with a feather, or by inhaling a little snuff. As no immediate danger need be feared, more active measures should be postponed until a physician can be consulted.

Foreign Bodies in the Throat. — The expulsion of foreign bodies from the throat can be aided by holding the child by the feet, head down, slapping him sharply on the back, and even jerking him up and down two or three times. If the body has passed into the windpipe there is great danger, and a surgeon must be summoned at once. This condition will be indicated by short, spasmodic coughing and the dusky appearance of the face.

Fractures. — When it is known or feared that a bone is broken, place the person in a comfortable position until the surgeon comes. It is better to wait a few hours for his arrival rather than to handle the parts in order to learn what the matter is. If, however, it is necessary to move the person at once, make an artificial support for the fractured bones. Place the parts in as natural a position as possible and put around the limb an even and thin layer of cotton, or wool, or other soft material. Place over this a number of pieces of lath, or strips of pasteboard, or any hard substance which will give firm support. The length and width of these **splints** must be regulated by the size and location of the bone injured. Bind the splints to the limb with anything which can be used as a bandage. In a fracture of the leg the injured limb may

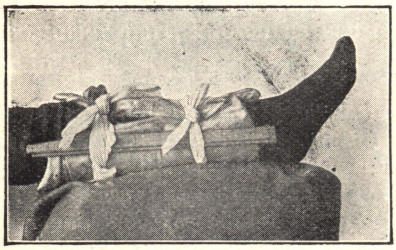

FIG. 111. — Temporary bandage for a fractured leg.

be placed on a pillow, the sides of the pillow brought up around it, and strips of cloth passed around the pillow, pressing it firmly against the leg, as shown in Fig. 111. Or if the accident occurs in the open air, where pads and pillows are not available, coats may be tied around the leg with handkerchiefs; and pads may be made of hay or moss. It should be possible to move the person without causing any severe pain.

Freezing. — An effort should be made to restore the frozen parts by rubbing with cold water or snow until the white color disappears. Heat should not be applied at first. If the whole body has been exposed to severe cold until there is danger that it is injured, it should be rubbed thoroughly with snow or cloths wet in cold water, until the circulation has been well established. Heat should not be applied at first, and only gradually afterward.

Hysterics. — Sometimes after excessive laughing or crying a person may have what resembles a severe convulsion. We call such an attack **hysterics.** In most cases the attack will pass off quickly if the person is left alone. Too much attention and sympathy only aggravate the trouble.

Jarring the Brain. — Children often become stunned by a blow or a fall. This is the result of shaking or jarring the brain. Have the child remain as quiet as possible, and in a short time recovery will be complete. If, however, this is not the case, a physician should be called.

Pain. — As a relief from pain, the **mustard plaster** is in common use. It is made by mixing an equal quantity of ground mustard and flour, adding sufficient water to make this into a paste; the white of an egg is even better than water. Spread this paste upon a cloth and lay it over the painful part. If the skin is very sensitive, some thin material may be placed between the plaster and the body. The

plaster should remain long enough to redden the skin, but not long enough to produce a blister.

Poisons. — Many persons are very careless with the drugs and chemicals they have about the house. They keep bottles and packages of all kinds on one shelf, whether they contain poison or not. This certainly should not be done. All bottles and packages should be carefully labeled, and moreover the poisons should be kept in a place by themselves. Indeed, every bottle or package containing a poison ought to have the word "POISON" upon it in large letters, and should be placed on a shelf out of easy reach, or, better still, be kept under lock and key. It is a wise thing to tie a paper cap over the cork of any bottle containing poison; then the presence of this paper and the necessity of removing it will serve as a reminder of what the bottle contains. It is never wise to pick up a bottle and quickly take a dose from it; first look at the label, and make sure you know what you are taking.

The first thing one should do in every case of poisoning is to try to find out what poison has been taken. Often the label of the bottle or package from which the dose has been taken will give the information, or the person who has taken the poison may be able to tell. In all cases, send some one for a physician while you are treating the case as best you can.

In treating cases of poisoning, an **emetic** is sometimes necessary. A tablespoonful of powdered mustard mixed in a glass full of clear water is a common emetic. The dose should be repeated every ten minutes until vomiting occurs. If the mustard is not at hand, try the same quantity of common salt. After taking these remedies, the vomiting may be hastened by thrusting the finger into the mouth until it touches the back of the throat.

The following are a few of the more common poisons with their antidotes : —

For muriatic, nitric, and sulphuric acids : Give three or four teaspoonfuls of baking soda or magnesia, or chalk or saleratus, dissolved in a glass of water. In an hour follow this with some soothing drink, as flaxseed tea. Do not give an emetic.

For carbolic acid or creosote : Give the white of several eggs. Give quantities of milk. Do not give an emetic.

For ammonia, solutions of potash, or soda, or lye : Give vinegar or lemon juice. Follow this with cream. Do not give emetics.

For nitrate of silver or lunar caustic : Drink half a glass of warm water in which a teaspoonful of ordinary salt has been dissolved. Use no emetic.

For corrosive sublimate and other preparations of mercury : Give the white of eggs. Use no emetics.

For preparations of copper, as verdigris, blue vitriol, and poisoning from eating food which has been cooked in copper vessels : Give the white of eggs. Use no emetics.

For copperas or green vitriol : Give a cup of water, in which has been dissolved a teaspoonful of ordinary baking soda. Later give raw eggs in milk. Use no emetics.

For arsenic, Fowler's Solution, paris green, or rough on rats : Cause repeated vomiting. Procure from the nearest druggist some freshly made hydrated sesquioxide of iron, and give two or three tablespoonfuls, in half a glass of water, every fifteen or twenty minutes, until four or five doses have been given.

For opium, morphine, laudanum, paregoric, soothing sirups, and all mixtures which produce sleep : Cause repeated vomiting. Give very strong coffee, without sugar or milk, freely. Keep the patient awake until the physi-

cian arrives, by walking or any other form of exercise, resorting to whipping, if necessary.

Poisonous Plants. — There are a few berries and plants that act as severe poisons when taken into the system. Among these might be mentioned henbane, poison parsley, indian tobacco, poison elder, wild parsnips, deadly nightshade, and the cardinal flower. The only safe way to escape poisoning is to avoid eating any plant or berry unless you know what it is. The treatment is to give emetics until there is free vomiting, after which strong hot coffee may be given for its stimulating effect.

FIG. 112. FIG. 113.

FIG. 112. — Virginia creeper.

FIG. 113. — Poison ivy, sometimes mistaken for the Virginia creeper. The poison-ivy leaf has three leaflets, and the Virginia creeper five.

Poison ivy (see Figs. 112, 113), poison oak, and poison sumac cause a painful rash, even if they but lightly touch the skin. Indeed, it is not necessary that there be actual contact, as the near presence of some of these plants may be all that is necessary to cause poisoning. Bathe the

skin frequently with a strong solution of ordinary baking soda. Covering the skin with vaseline is also useful.

The best treatment for poisoning from poison ivy is the local application of grindelia robusta. Procure one ounce of the tincture at any drug store, and mix it with ten ounces of water. Apply cloths moistened in this solution to the poisoned surface.

Poisoning also occurs from eating tainted meat, cheese, or ice cream, and from mistaking toadstools for mushrooms. In all these cases, give an emetic, unless vomiting has already occurred, and later give plenty of strong coffee.

FIG. 114. — Carrying a boy who has injured one of his legs.

Some Ways of carrying an Injured Person. — The easiest way to carry a person of about your own size, should it be necessary to do so without assistance, is upon the back, in the way the boy in Fig. 114 is carrying his friend.

If the person loses consciousness, or feels faint from the effects of the injury, it is best to get a blind, or door, or some similar flat surface, and lay the person carefully on it, by gently sliding him from the ground. When the destination is reached, leave the person upon this temporary stretcher until the surgeon arrives.

Sprains. — Place the injured joint in the position which is the most comfortable. Apply cloths wrung from hot

water about the joint, changing the cloths frequently, in order that the heat may be as great as can be endured. Continue these hot applications for at least half an hour. Then continue the applications with water that is not so hot. A surgeon should always be consulted.

Stings. — The stinger of wasps, bees, and other insects often remains within the wound. This should be removed with the fingers or with small forceps. Apply a strong solution of ordinary soda to the wound. Boys know very well that an application of mud gives prompt relief.

Suffocation from Gas. — When a person is discovered suffocating from inhaling gas, the first effort must be to revive respiration. If his breathing is very faint, or if it should cease altogether, perform **artificial respiration** as described for drowning, at the same time placing hot water bags or bottles around the body. As soon as he is able to swallow, give strong hot coffee as a stimulant. Keep in mind the fact that the person who has been breathing this bad air is suffering from want of oxygen. Place him where he can obtain all the fresh air possible.

Sunstroke. — Remove the person suffering from **sunstroke** to a cool place, and apply bags of cracked ice on or around the head. A method highly recommended is to remove all the clothing and pour cold water over the entire body. An ordinary watering pot may be held three or four feet above the body, and the water poured first upon the head, then on the chest and abdomen, and lastly on the extremities.

Occasionally persons are affected by the heat in such a way that they are very pale, the pulse is weak, and the skin cool. In these cases, the treatment should consist in applying warmth externally, and giving warm drinks internally. Such cases are often rapidly fatal.

CHAPTER XXXI

THE EMERGENCY NURSE

It often happens when some member of the family is taken suddenly ill, that one of the older children is called on to take the place of a nurse. Some children, even when very young, seem to have a natural ability for this work. There are many things which an inexperienced nurse can do as well as one more experienced : such as bathing the hands and face, brushing the hair, moistening the lips, cleaning the nails — mere trifles in themselves, yet they give comfort and cheer to the patient, and contribute in no small degree to his recovery. A few simple directions may increase the usefulness of the young emergency nurse.

General Suggestions. — A pleasant and cheerful countenance is sometimes the best kind of medicine for the sick. If you cannot take joy, hope, and good cheer into the sick room, you had better stay away. It is always well to take sunshine with you wherever you go, but it is especially important to take it with you when you enter the sick room.

Sleep. — It may be stated as a general rule, that a sick person should never be awakened when quietly sleeping. Unless the physician has given orders to the contrary, it is to be understood that the patient is never to be awakened to take medicine. Sleep is necessary to health, as we all know ; it is even doubly necessary for those who are ill.

Cleanliness. — Cleanliness is a very important item in the recovery of the sick. A sponge bath is always refreshing, and is an aid to recovery, if given in a way that does not tire the patient. If he is without fever and the body is cool, the water for bathing should be about the temperature of the body. If there is fever, the water should be cool.

Food. — There are a few foods which can be given to almost any sick person without danger, and with benefit. Milk is the most important of these. When there is fever, it should be given cold, a few swallows at a time. If a person is weak, and the body cold, warm milk may be sipped with great benefit. When milk is heated, it may be brought just to the boiling point, but should never be allowed to boil.

Fresh Air. — There should always be an abundance of fresh air in the sick room. Fresh air is necessary in health and becomes far more necessary in sickness. Therefore, see that the room is well ventilated at all times. Do not allow currents of air to blow directly upon the sick one, but prevent this by means of a screen, or an improvised shield made by throwing a blanket over a couple of chairs. Remember that even when a room is very cold, it may be filled with impure air; the temperature of the air has nothing to do with its purity.

A Well-lighted Room. — The nurse should always see that the room is properly lighted. Some persons appear to think that the sick room should be kept very dark. Light is essential to all who are well, and much more essential to those who are ill. Occasionally, to be sure, it may be necessary to have the room darkened in treating some eye trouble, but this should be done only when the physician has given strict orders to that effect. The room

should be so located that at some time during the day the sun shines directly into it. Even if the patient is suffering from a severe headache, and the strong light is very painful, it is better to shade the eyes and allow the sunlight to enter, than it is to keep the room dark all through the day.

Temperature. — It is essential to the patient's comfort that the temperature of the room should be right. If there is no fever, and if the person is inclined to be cool, the coverings should be warm, and there should be some heat in the room. If the person is feverish, the coverings should be light, and the room should be kept cooler.

CHAPTER XXXII

CONTAGIOUS DISEASES

Bacteria. — Bacteria are also known as germs and microbes. They are living bodies, so minute that the highest powers of the microscope are necessary in order to see them. So minute are they that millions of them, we are told, would not occupy a space larger than a small drop of water. The rapidity of their growth is almost incredible. If a few germs are placed in a solution favorable to their growth, such as milk or beef tea, countless millions of them will develop within a few hours.

The Destruction of Bacteria. — Bacteria may be destroyed by chemical agents that are known as **disinfectants.** They are also destroyed by the application of heat, for by raising the temperature to the boiling point nearly all forms of germ life may be destroyed. A few species of bacteria are not killed unless the boiling point is maintained from fifteen minutes to half an hour.

Some Bacteria are Useful. — All forms of **decay** are produced by bacteria. If meat or fruit or any other organic matter is left exposed to the air, it will sooner or later break down and soften ; after a time it may disappear altogether from view. This is entirely the work of these minute organisms. In the course of this softening process the organic matter not only is broken down, but also undergoes chemical change. After being acted

upon in this way the matter is in a condition to be taken up readily by plants as food.

Thus bacteria accomplish an immense amount of valuable work ; for they not only remove dead organic matter from view, but they also prepare this matter to become useful again as food for plant life.

Bacteria also cause Disease. — There are a number of diseases now known to be caused by germs. Among the diseases which physicians know, or fully believe to be caused by germs, we might mention consumption, pneumonia, diphtheria, typhoid fever, smallpox, yellow fever, cerebro-spinal meningitis, scarlet fever, measles, whooping cough, chicken pox, lockjaw, dysentery, and influenza.

Modes of spreading Disease. — It is easy to understand how readily these minute germs may be carried from one person to another, from one house to another, or even from one village to another. It is certainly very easy to see how one of these germ diseases might be contracted by a pupil who handles the books or pencils that had been used by one who was ill with such a disease.

Every pupil should be provided with his own pencil and paper, books, and drinking cup. When books are furnished the pupils, it is wise to require each pupil to cover his books with a good manila paper, which can be removed and burned at the close of the year, or as soon as the pupil is through with the books.

It is probably true that ordinary hard **colds** are due to germs. Therefore, persons with colds should be very careful about the use of handkerchiefs. Handkerchiefs should be frequently changed and the soiled one thrown immediately into boiling water, or placed temporarily in a paper bag which can be burned when the handkerchiefs are removed.

One agent in spreading contagious diseases is the **dust** which rises from the floors upon which expectorated matter has been deposited. The almost universal custom among men of expectorating upon sidewalks is most pernicious. Laws have been enacted in nearly all of our cities against this habit, and it is to be hoped that they will be enforced.

Still another source of danger comes from **insects.** It was positively proved during the Spanish-American war that typhoid fever was carried from camp to camp by means of flies. It has also been proved that yellow fever is transmitted from one person to another through the bite of a certain species of mosquito. When the mosquito bites one who is ill with this disease, it receives some of the disease germs within itself. Then when it bites a healthy person it transmits these germs to his blood. If the body is not in a strong, healthy condition, and so able to withstand the disease germs, the disease may develop as a result of the mosquito bite.

Protection of the Body. —The body is well protected from the action of the germs of disease; otherwise it would be difficult to understand how any of us escape being ill all the time. The outer covering of the skin is, in health, a great protection. The mucous membranes which line the respiratory and alimentary tracts also protect the body. While this protection may not be complete, even when these membranes are in a perfectly healthy condition, yet it is true that any break in their surface greatly favors the entrance of these germs.

Another means of protection resides within the body itself. Indeed, it might well be stated that the body is constantly fighting the germs of disease. This power of resisting disease is often called the **resistive power** of the body. It is believed to reside largely in the white corpus-

cles of the blood. These minute bodies have the power to destroy a limited number of germs, and they are therefore a great source of protection to the body.

It is also probably true that there always exists within the body, when in a perfectly healthy state, an antidote which is protective against the action of many of the poisonous germs. This antidote is known as an **antitoxin.** It is without doubt a great aid in protecting us from serious disease, acting in a manner somewhat similar to the antitoxin of diphtheria.

The "Toxins" of Bacteria. — When bacteria are placed in a medium favorable to their growth and development, they are capable of producing or manufacturing a "toxin" or poison. To illustrate: The germs of diphtheria would not produce such disastrous results if they only rested upon the membranes of the throat, and did not manufacture any poison. Indeed, it has been proved that the germs of diphtheria are in the throats of many healthy children who escape having the disease. In order to cause diphtheria, the germs must become active and produce their poison. When such a poison is produced, it is quickly absorbed into the blood, acting as a poison to the whole system. The danger from diphtheria, therefore, is from the toxin or poison produced by the germs of diphtheria.

The Antitoxin of Diphtheria. — As we have antidotes for many kinds of poison, so we have an antidote for the toxin or poison of diphtheria, called antitoxin. This is a preparation especially made to counteract the poisons of this disease, which have been absorbed into the blood. It destroys the power of these poisons, and if administered in time will, in nearly every case, prevent a fatal termination of the disease.

[1] **Consumption.** — Consumption, more accurately called **tuberculosis,** is now known to be due to a germ called the tubercle bacillus. The sputum or expectorated matter of consumptive persons is filled with these germs. When the sputum dries it is easily powdered, forming a part of the atmospheric dust. This dust is inhaled by people, and if a person is not in good health, the germs may find a suitable soil in which to grow and produce the disease.

All persons who have consumption should be under the watchful care of a skilled physician, and his directions should be carefully carried out. He will certainly order that every effort be made to destroy all expectorated matter as soon as possible, and that under no circumstances should it be allowed to become dry. Small pieces of cloth or little paper cups should be carried, and when these have been used they should be burned at the first opportunity. If a china cup or cuspidor is used, it must be partially filled with water, and should be frequently emptied, and after emptying washed with boiling water.

Pneumonia. — Pneumonia is an inflammation of the lungs, caused by a distinct germ. The germs are found in the sputum of the person who has the disease. These germs are found also in the mouth and throat of persons who are apparently in the best of health, and who escape having the disease. This may be due to the fact that the breathing apparatus is so healthy that the germs do not find a suitable place in which to grow; or it may be due to the action of the white corpuscles or to the natural antitoxin of the body.

Influenza. — There is every reason to believe that influenza, also, is due to a germ, which is inhaled in the air; therefore, discharges from the nose and throat of a person who has influenza should be promptly destroyed.

[1] See special chapter on Tuberculosis.

Diphtheria. — The germs of diphtheria are very active, and the most stringent measures are necessary in order to prevent and restrict the disease. All discharges from the nose, mouth, and throat should be destroyed at once, as they probably contain immense numbers of these virulent germs. The patient should be placed in a well-lighted room in which there is little furniture, and no one should be allowed to enter it but the physician and nurse. If there is diphtheria in the neighborhood, village, or city, a physician should be consulted without delay whenever there is any soreness of the throat. This is a wise precaution, for it frequently happens that what appears at first to be a simple sore throat may prove to be a serious form of diphtheria.

Typhoid Fever. — Typhoid fever is usually caused by drinking water in which there are germs of the disease. Sometimes it is produced by milk made impure by washing the milk cans with water which contains the typhoid fever germs. Milk is also sometimes adulterated with such water. Ordinary filters will not remove these germs from the water. When filtering is properly done on a large scale, as in city water works, the purifying of the water can be accomplished in a very satisfactory manner. Water can also be made free from these germs by boiling. Typhoid fever is now called an unnecessary disease; that is, no one need have this disease if only the water supply is pure. Here is another reason why the question of water supply is so very important.

Scarlet Fever. — A germ probably causes scarlet fever also. The person who is ill should be placed in a well-lighted room, and no one should be allowed to enter it but the doctor and nurse. All discharges from the nose, mouth, and throat should be immediately destroyed.

Later, when the body is "peeling," special care is necessary in order to destroy the minute scales, thus preventing their becoming a part of the dust of the atmosphere, and a possible source of contagion to others. When a person has been exposed to scarlet fever, the disease may show itself in a very short time. It generally appears in less than seven days after exposure, quite frequently in only two or three days, and sometimes in only a few hours.

Measles. — Measles is probably a germ disease. It is easily spread among children ; hence the same precautions should be taken as for other contagious diseases, in order to prevent its spread. After exposure to measles, it is usually from ten to fourteen days before the disease develops.

Whooping Cough. — As whooping cough is a disease which is easily communicated from child to child, great care should be taken that the one who has it does not mingle with other children, and thus expose them.

Smallpox. — Smallpox is spread by means of the particles which come from the surface of the patient's body. As vaccination is a protection against contracting the disease, no one should neglect this precaution. It is best to be vaccinated at least once every five years, for one vaccination does not necessarily protect for life. When smallpox is prevalent, a person should be revaccinated, without regard to the length of time since the last vaccination. When the germs of smallpox have entered the system, it is usually ten days to two weeks before the disease manifests itself.

Isolation. — The word "isolation" means "to place by itself," or "to separate from others." But this does not mean that a person who is to be "isolated" must be placed alone in a room and neglected. It does mean, however, that every precaution is taken in order that no one shall

come near the patient except the nurse and the physician. The fact that a person has a light case of some contagious disease does not lessen the necessity of isolation; when communicated to another person the disease might be so severe as to prove fatal.

When the attendant leaves the sick room, the outer clothing should be changed, and the face, hands, and hair thoroughly washed. If there are several children in the house, and one of them is taken ill with diphtheria or scarlet fever, the children who are well should not be allowed to attend school or to mingle in any way with other children, until all danger of their conveying the disease is past.

Disinfection in the Sick Room. — A **disinfectant** is an agent that destroys disease germs. The simplest and one of the best disinfectants is heat. Boiling for half an hour is sufficient to destroy nearly all germ life. All cups, spoons, and vessels of every description used about the sick room should be placed in water before being taken from the room, and then should be thoroughly boiled. All clothing and bedding which will not be injured thereby, should be treated to the boiling also. The modern method of disinfecting with steam under pressure is very effective, and is used in many cities. It requires a plant constructed for that purpose.

Among the chemical agents which are marked disinfectants might be mentioned bichloride of mercury or corrosive sublimate, formic acid or formaldehyde, and carbolic acid. These are most powerful disinfectants, but they are also very powerful poisons. Heat is so good and so safe a disinfectant that it can be made to meet all ordinary needs.

After the removal of the sick person from the room, everything should be thoroughly disinfected. If the bed-

ding, garments, and furniture are not too valuable, they would better be burned, or whenever possible they should be boiled for at least half an hour. The following method of disinfecting a room is a good one to adopt when the contents of the room cannot be burned. Spread all clothing and bedding loosely over the chairs. With pieces of cloth or cotton tightly close every opening about the room so far as it is possible, pasting strips of paper along the sides of the windows and doors. In order to prevent any danger from fire, take an ordinary washtub and in it place water to the depth of a couple of inches. Set a shallow iron pan or a low iron kettle upon a couple of bricks in the center of the water. For a room ten feet square, use three pounds of sulphur. Break the sulphur into small pieces and moisten them slightly with alcohol. Put the sulphur in the iron dish and set it on fire, using care not to breathe the strong fumes which will immediately arise. Promptly leave the room and close the door tightly. After twenty-four hours throw open the doors and windows and allow the gas to escape. Wash all the woodwork with soap and water, and if possible have the room newly papered and painted. It is wise to allow the contents of the room to be exposed to the outdoor air for a day or two after the disinfecting, if the weather will permit.

If one is living in a place where there is a Board of Health, it is always better to notify one of its members when a room needs to be disinfected.

CHAPTER XXXIII

TUBERCULOSIS

"It is in the power of man to cause all parasitic (germ) diseases to disappear from the world."—*Pasteur.*

TUBERCULOSIS, the most widely spread disease that affects human beings, kills, approximately, over two million persons every year throughout the world. One hundred and fifty thousand die from it each year in the United States and over twelve thousand in Canada. It causes one death in every four occurring between the ages of twenty and forty. Thus it finds most of its victims at the active working age and carries off young men and women entering upon the serious work of life; fathers and mothers of families, bread-winners and citizens at their most useful period. It must then be apparent to all that Tuberculosis is one of man's greatest enemies. Now with knowledge of an enemy who is liable to attack him, what would any intelligent person do? He would ascertain how and by what means this enemy made his attacks. He would study his strength and his weakness. He would also try to know where and in what points he himself was weakest. Let us, then, consider the enemy, Tuberculosis.

Tuberculosis is a disease caused by a living germ—a tiny plant which can be seen only through the microscope; indeed, so small is it that many thousands of them piled together would make a heap too small to be visible to the naked eye. It is a weakly microbe, and unless placed in

favorable conditions, it soon dies. It does not multiply outside the living body of man and certain animals. Exposed to the sun's rays it quickly dies, but left in dark, foul, damp places, it may live for months or even years.

The germs may enter the body in a number of ways, but for practical purposes we need only consider two channels, namely, by the respiratory tract and by the digestive tract.

When the germs are in a dry state they may float in the air. When they rest on the ground they become attached to particles of dust, which, when stirred up, as in sweeping, may fill the air. In order to clearly understand the importance of this, watch a ray of sunlight which has passed through a chink into a darkened room. It will then be seen how dust may be breathed into the lungs, or may lodge in the throat, or be swallowed. Children creeping about the floor may get them on their fingers, or on toys, and so carry them to their mouths. They may enter the digestive tract in the food we use. There are other ways by which Tuberculosis germs may be conveyed, but the above-named are the most frequent.

Let us now see what happens to the germ when it has entered the human body. In order to understand how it acts we must first know what this germ likes best and under what conditions it lives, thrives and multiplies. We know that the germ, when outside the body, flourishes in dark, foul and moist places, and dies in places dry, clean and exposed to sunlight. When the germ enters the body it practically follows the same law. Under one set of conditions (unhealthy) it is likely to live and multiply, whereas under other conditions (healthy) it is almost certain to fade away and die. Here, then, it is evident that two elements are essential to the development of Tuberculosis. The first is the entry into the body of the germ (tubercle bacillus) and the

second is the condition of the body which by natural ill-health or gross neglect has been allowed to become suitable soil for its development.

This suitable soil may be inherited, or acquired. It is inherited when parents are unhealthy, from any cause, especially Tuberculosis. It is acquired when a healthy person overworks, or worries too much; is intemperate; sleeps or works in over-crowded, ill-ventilated rooms; does not sustain the body by sufficient good and healthy food; it is also acquired when the body is weakened by sickness, such as pneumonia, typhoid fever, grippe, etc.

The bodies of such persons form suitable soil for the growth of the Tuberculosis germ; and, since we know that nature has provided, within our bodies, certain conditions which repel or destroy disease germs, it will be seen how necessary it is to maintain, at its highest efficiency, the health which nature gave us.

Tuberculosis, then, is caused by the entrance and lodgment in the system of the tubercle germs, or bacilli. The lungs, the bones, the intestines, the joints, the brain, etc., may be the seats of trouble, but the part most frequently affected is the lung. When these germs lodge and grow in the lungs the disease is called Consumption.

Once the tubercle bacilli, or germs, gain lodgment in a body suited to their growth, they produce little lumps called tubercles. In the lungs these lumps grow, soften, and gradually break down. This process of growing, softening, and finally "breaking down" into matter (pus), is usually very slow. During all this time nature's defences are fighting the advances of the germs. Where they lodge and live the tissue is destroyed, and as a result the whole body is weakened. Thus, the bacilli more easily advance to other tissue, and, unless an effort is made to build up the bodily strength and so assist nature's efforts to fight the enemy, the

disease will continue to advance. Thus nature is finally overcome and death eventually results.

Where the germs come from. — For hundreds of years, doctors were unable to learn the true cause of Consumption, and the popular idea prevailed that the disease was hereditary and could not be prevented. In the year 1882, Dr. Koch, of Germany, found germs in the sputum of persons suffering from Consumption. He put these germs in glass tubes with a preparation of blood, and placed the tubes in ovens at the temperature of the living body. After a few days the little germs began to grow and multiply. Some of them were taken and injected into guinea-pigs and in a few weeks the guinea-pigs became consumptive, and later, died. Repeated experiments produced the same results. This and other experiments proved that the tubercle germ was the only cause of Tuberculosis. It was also shown that the germs increased to enormous numbers in the deposits or lumps formed. When these lumps break down, as they so often do, in the lungs, the broken-down matter or pus is coughed up and spat out by the patient. This sputum has been frequently examined and has been found to contain not only hundreds, but millions of germs. When the deposit is in the brain, bones, intestines, etc., it is clear that the danger of spreading it around is less likely to occur than when it is in the lungs. Here, then, we have a knowledge of overwhelming importance. In fact, this knowledge leaves it in our power to stamp out this terrible scourge of Tuberculosis.

The full significance of Dr. Koch's discoveries in the prevention of Tuberculosis has been but slowly comprehended. These discoveries were made twenty-six years ago, and, even now, a part of the medical profession and a large proportion of the public fail to grasp their vast influence on the happiness and prosperity of the human race.

The first thing, then, to be done is to catch and destroy

every particle of material coughed up and spat out by a consumptive. If this could be done completely, the spread of the disease could be almost checked.

The breath of the consumptive does not contain the germs, nor can they get into the air around him in any way except through the drying of his sputum (spit), or by coughing without covering the mouth. A consumptive is, therefore, not in any way dangerous to speak to, or sit with, so long as he is scrupulously clean in his habits, catches and destroys every particle of expectoration, and always coughs into a napkin or cloth and burns it.

Spitting.—I hesitate to use the word "spit." It sounds objectionable and its use almost calls for an apology. If the mere word is offensive, how much more so must the act be?

The filthy and dangerous habit of spitting cannot be too severely condemned. If the dictates of decency will not influence, then common humanity should guide, for there are many diseases, other than consumption, conveyed through the spit.

The injury done to many by spitting is a matter of indifference to some people. As a result it is now made contrary to law to spit on floors in public places, or in cars, or on sidewalks. This law is necessary for the careless and ignorant, but it is expected that thoughtful and honest-minded citizens will abstain from acquiring the habit. When it is absolutely necessary to spit, do so in such a manner that persons are not liable to carry it on the soles of boots, or on long, trailing skirts into their homes. There is little doubt that many deaths have resulted from carelessness in this respect.

Symptoms of Consumption.—The beginning of all cases of Consumption is by no means the same. Many people have Consumption, but the disease is checked before symptoms appear which would lead to the suspicion that it existed.

In such cases nature's resisting powers have conquered. This proves, if indeed proof were needed, the advantage of keeping these natural resisting powers at their highest state of efficiency, by living a good, clean, healthy life.

The first symptom of the disease may be loss of appetite, loss of weight, fatigue on slight exertion, general feeling of weakness, lack of energy and ambition, rapid pulse, fever in the afternoon and evening, and a cough which is most noticeable in the morning.

These symptoms are often so slight that they are not noticed, and indeed the onset is so slow that the disease is often firmly established before the suspicions of the patient, or the patient's friends, as to the nature of the trouble, are aroused.

Blood coming from the lungs is a most serious symptom.

Any of these symptoms should cause a patient to seek *at once* the most competent medical advice.

What can be done for Consumptives.—Unfortunately, many consumptives fail to heed the advice given them. This is especially true in the earlier stages of the disease, and it is unfortunate not only for the consumptive, but for others also.

Consumption is curable when proper treatment is begun early, by adhering to the following rules : —

1st. Fresh air all day and all night.

2nd. Rest and exercise under careful and constant medical guidance.

3rd. Plenty of good, plain food.

How to avoid Consumption.—The important points in the prevention of Consumption are, pure air, clean surroundings, an abundance of light, cleanliness in the home, office, or workshop, good food properly cooked and properly masticated, moderate living, and sufficient sleep in rooms to which fresh air is freely admitted day and night. The excessive use of alcoholic liquors lowers vitality and so favors the

disease germs. Exercise in the open air, walking erect, and breathing correctly, that is, through the nostrils; not to sleep in a room with a consumptive, if it can be avoided, and not to drink from any glass, cup, or vessel used by another, unless it has been carefully washed, are points to be especially emphasized. Above all, do not neglect a cold or cough; countless graves are filled with those who have done so.

TUBERCULOSIS; WHAT IT IS

A CATECHISM ON CONSUMPTION ISSUED BY THE DEPARTMENT OF HEALTH, NEW YORK CITY, 1908.

1. What is Pulmonary Tuberculosis or Tuberculosis of the Lungs?

Tuberculosis is a very common and often fatal disease of the lungs, which is given by the sick to the well. It is largely spread by the filthy habit of spitting.

2. What is it often called?

Consumption. The disease "consumes" you.

3. What are some of the early symptoms of the disease?

Cough, fever in the afternoon and loss of appetite, strength and weight. Sputum or phlegm is coughed up, and sometimes there is hemorrhage (bleeding) from the lungs.

4. What causes Tuberculosis?

A tiny living germ or bacillus, called the tubercle bacillus, too small to be seen without a powerful microscope.

5. Does Tuberculosis affect other parts of the body besides the lungs?

Yes; the bones, joints, glands of the neck, and other parts are often attacked.

6. How does one person "infect" or give Tuberculosis of the Lungs to another?

By means of the tubercle bacilli in the matter (phlegm, sputum) coughed up from the diseased lungs, which often contains millions of the germs.

7. How do the germs get out of the body of one who has Tuberculosis?

In the phlegm or sputum which is coughed up, and in the little drops, too small to be seen, which are sprayed out when persons with Tuberculosis cough or sneeze.

8. Can the tubercle bacillus live outside the body?

Yes. If the sputum is discharged on the floor, or on carpets or clothing, the germs may live for months, especially if they lodge in a dark, moist place. But out of doors, in the sunshine and free air, they quickly die.

9. How does one get Tuberculosis of the Lungs?

Tubercle bacilli, coming from the diseased lung of some person who has Tuberculosis, are taken into the healthy lungs, and growing there, cause the disease.

10. How do the bacilli get into the lungs?

They are breathed in, either in dust which contains dried and powdered sputum, or in the tiny drops of sputum sprayed out by persons with Tuberculosis when they cough. The bacilli sometimes enter the body in food and drink, especially milk.

11. What kind of people are most likely to get Tuberculosis?

Those who are sickly and run down from other diseases; from intemperance; from poor or insufficient food; from living in dark, overcrowded rooms; or from over-work. Their weakened systems cannot resist the bacilli.

12. What common sickness frequently favors the development of Tuberculosis of the Lungs?

An ordinary cold or cough which is neglected. A cold does not cause Tuberculosis, but it helps the germs to get a foothold in the lungs and multiply there.

13. What else may lead to the disease?

Studying, working or living in dusty rooms, especially where the air is bad from poor ventilation and overcrowding. Tubercle bacilli are often present in such rooms, especially where a careless person has spit on the floor.

14. Is it safe to move into a house or rooms in which a person with Tuberculosis has lived?

No; not until the house or rooms have been thoroughly cleaned and disinfected or renovated.

15. What is the first and most important rule to observe to avoid getting Tuberculosis?

Keep as strong and healthy as possible.

16. Why?

When the tubercle bacilli get into the body or lungs of a healthy person, they do not multiply, and are usually soon killed; while in the lungs of a sick or weakly person they often increase in numbers and produce Tuberculosis.

17. What things help in keeping one well?

Fresh, pure air in the home, school-room and work-room, proper food, cleanliness, temperance in all things, leading a regular life, and living out of doors as much as possible.

18. How can one get fresh, pure air?

(*a*) By keeping out of doors and avoiding dust as much as possible. (*b*) By admitting plenty of fresh air several times a day to the rooms in which one lives or works or studies. (*c*) By keeping at least one window of the bedroom open all night. (*d*) By cleaning with damp cloths and brooms (never using a dry broom or duster) to prevent dust from floating in the air of the room.

19. What ought one to do when a cough lasts more than two weeks?

Go to a doctor or a dispensary and have the lungs examined.

20. What habits of school children are dirty, dangerous and to be avoided?

(*a*) Putting the fingers, coins, pencils or playthings in the mouth. (*b*) Eating candy or chewing gum which other children have had in their mouths.

21. Is bathing a necessity?

Yes. Every one should take a warm bath with soap at least twice a week, and those who can should have a cold bath every morning.

22. Is the drinking of whiskey and other forms of alcohol injurious?

Yes. They weaken the body so that it cannot resist disease germs. Many drunkards have Tuberculosis.

23. How can one keep from catching cold?

(*a*) By always having plenty of fresh air night and day, and taking a cold bath every morning. (*b*) By keeping away from, and complaining of, persons who have a cough and who spit on the floor or sidewalk. (*c*) By avoiding exposure to cold and damp after such diseases as measles and whooping cough. (*d*) By keeping the feet dry and avoiding exposure to cold or winds, when very warm or very tired. (*e*) By avoiding close, overheated rooms, crowded with people.

24. Is it dangerous to live or work with a person who has Tuberculosis?

No, not if he is careful and cleanly.

25. Of what must he be careful?

To destroy all the sputum coughed up.

26. What is the best way to do this?

A person with Tuberculosis must never spit on the floor or sidewalk or in street cars, but always into a cuspidor or into a paper cup, which he should have with him at all times and which can be burned. Old rags or cheese-cloth squares which can be easily burned, may also be used.

27. How can he keep from spraying out tiny drops of sputum when he coughs, laughs or sneezes?

By holding a handkerchief or a square of cheese-cloth in front of his mouth whenever he coughs or sneezes.

28. Should a person with Tuberculosis sleep in the same bed with any one else?

No, and if possible, not even in the same room.

29. Can Tuberculosis be cured?

Yes, if treatment is begun early.

30. How?

By good food, fresh air and rest, and such medicines as the doctor may prescribe.

31. Where are these best obtained?

In hospitals located in the country and called sanatoria.

32. When a person learns he has Tuberculosis, what should he do?

Go at once to a doctor or dispensary, and do as advised. **Do not waste time and money** on patent medicines, advertised cures or advertising doctors. **They are worthless.**

Tuberculosis kills more people than any other disease. Many grown people and children who have coughs, have Tuberculosis without knowing it, and they can and do give it to others. So you must not spit on the sidewalks, playgrounds, or on the floors or hallways of your home or school. Not only Tuberculosis, but other diseases are spread in this way.

Spitting is dangerous, indecent and against the law.

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